APPLIED MECHANICS Reviews

A CRITICAL REVIEW OF THE WORLD LITERATURE IN APPLIED MECHANICS AND RELATED ENGINEERING SCIENCE

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THE RATIONAL MECHANICS OF MATERIALS— PAST, PRESENT, FUTURE

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Mathematics is a strong instrument for study of materials, not only for learning predictions from accepted theories but even more to clarify and discipline concepts in creating new models of experience. Here I present not a survey but a sampling of Rational Mechanics. That we here consider rational methods does not necessarily imply that, in some contexts, irrational ones may not be more profitable.

Problems are selected partly from the continuance of their moment, historical and actual, and partly to illustrate unity of concept in the face of time and of variety of physical application.

* * *

Jordan of Nemora (13th Century) proposed the problem of the elastic curve and attempted to prove it to be an arc of a circle. Beeckman (1620) saw that the outer fibers are extended, the inner ones contracted; therefore there is a neutral or unextended fiber in the interior. Thus began the dichotomy in the theory of rods and shells that still exists today. On the one hand, the rod is represented by a curve, the shell by a surface, and it is the forms of these we are to determine. On the other, a theory for rods or shells must be based on or derivable from a representation of the elasticity of solid bodies. James Bernoulli faced this problem in a series of deep and difficult researches (1691–1705). He wished to avoid assuming any particular elastic law, such as Hooke's law for the fibers. While he obtained a correct differential equation for the neutral line, his attempt to connect it with three-dimensional concepts is partly faulty. Parent (1713) showed the correct relation between the neutral line and any assumed law of interior tension; he also mentioned the necessity for interior shear stress in a terminally loaded beam. Euler (1727, 1759) was content to adopt Hooke's law and hence was able to derive James Bernoulli's law of bending in the explicit form $M = EI(r^{-1} - R^{-1})$. When Hooke's law is assumed, the neutral line is the central line. In respect to this class of problems, Saint-Venant's solution within the three-dimensional linear theory (1856) is a retreat, for it assumes the very result Bernoulli and Parent sought to avoid. The problem of the neutral line, conceived within the modern theory of finite strain, is still open today.

Euler determined and classified all possible forms of finite deflection of a terminally loaded, initially straight elastica (1743); at the same time, he found the curved form that a band must have in order to be bent straight by an assigned terminal load. In solving the analogous problem for hydrostatic pressure, which includes as a special case the piston-ring problem, I remarked [1954, 5] that for problems of finite deformation in general, it is easier to find the shape a body must have in order to take given form when loaded than it is to solve the direct problem. Interesting cases of large strain remain to be solved thus.

In the course of Euler's determination of elastic curves, he discovered the famous buckling formula, nowadays often derived by a linearized theory in manifest contradiction with experience. By trial of special cases, Lagrange (1773) was led to conjecture that among all columns of given height and volume, the strongest in compression is the cylinder; he then gave a proof that this is so, but the proof is false, and so is the result. H. F. Weinberger and J. Keller have shown me methods whereby the problem can be solved; by suitable entasis, the strength can be increased by a factor of 4/3, but unfortunately the best form has zero area at the ends. Perhaps much of the increased strength can be retained without sacrificing all the contact area. That the response to shape is sensitive is shown by two results of Euler (1757): a pointed column has no strength, and two like conical frusta set back to back are always weaker, whatever their slope, than a cylinder of equal length and volume.

The first adequate theory of torsion is that of Saint Venant (1855). Many of the most intense studies of the concepts of mechanics seem to converge to form the basis for this theory.

While the modulus of bending, EI, was calculated correctly without developed ideas of stress and strain, this is not true of the modulus of torsion. The creation of the prerequisite concept of stress offers a striking case of the rational method, for, in historical truth, every one of the many gradual steps toward it was taken by mathematical, or imaginative means alone. Galilei's explanation of why a long rope is not weaker than a short one (1638) and Pardies' beautiful solution of the suspension bridge problem (1673) both tacitly assume that, in a flexible line, the action of one part on its neighbor is equi-

pollent to a tangent force at the imaginary junction. This concept of tension was formalized by James Bernoulli, who finally derived differential equations for a plane, perfectly flexible line subject to arbitrary distributed load (1691–1704). But this would not do for an elastic band, and his theory of the elastica grew from a distinct line of thought. Euler struggled all his life long to unite the flexible string and the elastic band within one embracing concept. Finally he realized that a force normal to the line, or shear force, is needed, as well as a couple; thus he derived the general equations of equilibrium for a line bent in its own plane, no material constitutive equation being presumed (1771).

But meanwhile Euler had developed a similar idea for fluids. Newton (1687) had proposed a fluid model for the earth, but his concepts of mechanics in general and of fluids in particular were insufficient even to formulate the problem. Nevertheless, by assuming that two perpendicular columns of fluid, one polar and the other equatorial, meeting at the earth's center have equal weight, he found a kind of solution in a special case. Huygens (1690) proposed as an alternative principle that the plumb line falls perpendicularly to the surface of an ideal ocean. Clairaut (1743) showed the insufficiency of Newton's and Huygens' principles and found a criterion that the field of force must satisfy in order that equilibrium may be possible.

Newton had created also a brilliant but faulty theory of efflux of fluid from a vessel (1687). Guided by this and other early erroneous work, Daniel Bernoulli succeeded in deriving, by precarious concepts, his celebrated relation between the speed and the manometric pressure in a tube of varying cross section (1730). To set this theory straight in respect to mechanical principle, John Bernoulli (1742) introduced the interior hydraulic force as being equipollent to the force exerted by the fluid to one side of a slice on that to the other, and assumed that it is normal. D'Alembert (1749) obtained the first theorems on the velocity field of a fluid motion, including the all-important formula for the acceleration, but he argued fallaciously that only potential flow is possible, and thus he was able to slip around the need for introducing any pressure except a resultant force, which turned out to vanish in the case of an immersed body.

Euler succeeded in unifying all three earlier groups of theories—figures of equilibrium, hydraulics, and potential flow—in a single one (1752). To do so, he postulated that the action of the fluid outside any imagined closed diaphragm on that inside is equipollent to a field of normal vectors on the diaphragm. This led to the concept of interior fluid pressure. (It was only in this way that the general equations of hydrostatics were discovered, as a corollary of the equations of motion.)

Finally Coulomb (1773) revived Parent's idea of an interior vector that is not normal; that is, of shear stress, but Coulomb considered only a plane area and did not have sufficient mathematics to make his idea fruitful.

Each of these three independent concepts of stress had its limitations. By dropping the limitations and keeping the common features, and by developing the appropriate mathematics, Cauchy (1822) created the general theory.

With this theory, James Bernoulli's hope of inferring some properties of continuous systems without presupposing any constitutive relation becomes realizable. Signorini [1932, 1] derived a general and simple theory of mean values of the stress, yielding among other results lower bounds for the stress in many general problems. Following a treatment of the plane problem by Airy (1862), Maxwell (1868) and Morera (1869) solved the general equations of equilibrium; that is, they found the most general equilibrated stress. Their results were shown by Gwyther (1912) and B. Finzi [1934, 1] to be included in a general equation in tensorial form, and by obtaining the solution in a flat space of any dimension Finzi found, in particular, the most general dynamically possible field of stress and velocity. Finzi's solution has been given an elegant proof by Dorn & Schild [1956, 1]. The problem is more difficult for curved membranes; L. Finzi (1956) and I [1957, 6] proved that it is equivalent to calculating the conditions of compatibility, and our results nearly succeed in putting the general solution of Storchi [1950, 2] into invariant form. Cf. also [1959, 5].

The theory of strain developed still more slowly. That relative rather than absolute change of length should be considered in material properties was stated by Beeckman (1630) and emphasized by James Bernoulli (1705) though neglected by empiricists such as Hooke (1675) and Young (1807). The essential concept of shear strain was introduced, at last, by Euler (1766), but only in the context of perfect fluids, where it is rather a curiosity. All attempts prior to 1820 to formulate theories of twisting of rods, bending of shells, or deformation of solids were abortive from lack not of any physical law or experimental fact but of sufficient differential geometry to describe the phenomena observed in daily experience.

Cauchy (1822) had the insight to understand that a point space is defined to within a rigid motion by its arc length or fundamental quadratic form. This yields, at once, the theories of finite and infinitesimal strain.

The program of one-dimensional elastic theories as defined by a relation between (force)/(area) and (change of length)/(length) was laid down by James Bernoulli (1705), who argued that a relation of this kind characterizes a material rather than just a particular specimen. Bernoulli wished to avoid presuming any special relation; like most early theorists, he rejected Hooke's law because it is contradicted by experiment on strains or deflections of magnitudes then measurable. (The distinction between large strain and large deflection was first pointed out by Saint Venant (1844).) Bernoulli's work implies use of the tangent modulus of extension. The linear modulus, or "Young's modulus" (imperfectly transcribed, apparently from Euler's work, by Young (1807)), was used by Euler (1727 onward), who was the first theorist to put some trust in Hooke's law; Euler finally gave a formal definition of the modulus as the stress required, theoretically, to produce unit strain and inferred from measurements of buckling loads that very large stresses may produce minute, at that time immeasurably small, extensions (1776).

Combining the concepts of stress, strain and material modulus furnishes Cauchy's extension (1822–1829) of James Bernoulli's program to spatial bodies. Cauchy was influenced by the ideas of Fresnel (1821–1823) and of Navier; the latter had derived special elastic and fluid theories from molecular models (1821–1822). Cauchy obtained the general linear theory of small elastic strain.

Within this theory, to approach the problem of torsion it would seem necessary to know the distribution of stress or displacement on the ends of the twisted beam. This information is not available in practice, and the behavior of beams in torsion is more or less independent of it. Perception of this fact led Saint Venant to construct a beautiful special solution of the torsion problem and to conjecture that the resulting modulus of torsion is sufficiently accurate to be used for long beams in cases when the end loading is not that which his special solution presumes but is merely equipollent to it. This idea, generalized as "Saint-Venant's principle of equipollent loads," led to a major problem in linear elasticity, for such a result, if true, must be a mathematical consequence of the general equations. After a century of trials, a clear formulation was achieved by v. Mises (1945) and analyzed with finality by Sternberg in a paper already classical [1953, 2]. This concept of Saint-Venant's principle refers to a family of solutions corresponding to a family of loads applied in a family of vanishingly small areas, and the results are expressed in terms of the order of the radius of the region. Ele-

gant as is the work, I suggest that the formulation of the problem is in one respect too general, in another, too special. E.g., for torsion, it is not the entire distribution of stress and strain in the beam that is of interest, but rather certain simple properties, such as the modulus of torsion and the maximum stress. To require that all properties be insensitive to variation of equipollent loads is too much; to compare only loads in vanishing regions is too little. In application of the principle, a body is given, and in the cases to be compared the loads are applied all over a fixed finite region. For any end load, the modulus of torsion may be defined as the ratio of the applied couple to the mean value of $\partial^2 u_\theta/\partial r \partial z$ over the whole beam; this is a functional of the end loads, and a form of Saint-Venant's principle would assert that as the end loads are varied within the class of equipollent loads, this functional is nearly constant. The length of the beam may have its influence in determining whether the above definition of torsional modulus, or any definition, is appropriate. A start was made by Purser (1906) and Tedone (1911) with explicit calculations for the circular cylinder subject to axisymmetric shear; the modulus of torsion turns out to be a constant, supporting the conjectured principle but not illustrating the mathematical difficulty of this still open problem.

Cauchy's idea of elasticity, that the stress is a function of the strain, was first formulated in full generality for finite strain by Reiner (1948). The lateness of this proposal was caused by the general acceptance, meanwhile, of a more restricted idea of elasticity hinted by Daniel Bernoulli (1738) and Riccati (1754), made definite by Green (1839–1841), and corrected by Kirchhoff (1852) and Kelvin (1863), namely, that the work of deformation is stored and available for reversing it. This idea, a special case of Cauchy's, it is convenient to call "hyperelasticity." Finger (1894) obtained the general reduction of the equations of hyperelasticity in the isotropic case. The theory seemed hopelessly difficult until it was revived by Rivlin (1948 onward), who found several enlightening solutions, including those for torsion of a cylinder and for bending of a bar. Rivlin contributed two basic ideas: He saw the far-reaching simplification that results when the body is assumed incompressible, and he saw that it is often possible, by inverse methods, to determine solutions valid for all forms of the stored energy function. Comparison with the results of experiment determines the two derivatives of the stored energy, for a given material, as functions of two independent strain invariants. The material constants of the linear theory are replaced by material functions. While Ericksen has shown that solutions of this kind are few [1954, 2] [1955, 2], Rivlin's approach clears away a mass of semi-empirical guesses and "approximations" and lays the foundation for mastery of finite elastic deformation. Poynting's observations (1909–1913) that a twisted shaft elongates are easily explained; Green & Shield (1951) solved the classical problem, outstanding since the experiments of Coulomb (1777–1784), of calculating the increase of the modulus of torsion that accompanies large extension. A systematic expansion procedure proposed by Signorini [1936, 1] reduces a problem of the finite theory to a succession of problems in the linear theory; this method was rediscovered and put in easily applicable form by Rivlin & Topakoglu [1954, 3]. Stoppelli [1954, 4] [1955, 6] has proved that there really is a solution of the type presupposed.

That the stored energy cannot be a fully arbitrary function is clear from the linear theory, where it is a quadratic form that is supposed to be positive definite in order that a body accept rather than give out work when deformed. In the finite theory, I pointed out that a correct thermodynamic condition is not obvious and proposed a mechanical one (1952) [1956, 7]; such a condition is necessary, e.g., if the theory is to predict that only lengthening, not shortening, of an incompressible cylinder can result from torsion. Hadamard [1903, 1] had established a connection, for the general theory, between elastic stability and the propagation of waves, and had given differential inequalities sufficient for stability; cf. also Ericksen [1953, 1]. Work of Baker & Ericksen [1954, 1] and of Ericksen & Toupin [1956, 2] finds clearer mechanical restrictions and reveals some consequences of Hadamard's conditions with respect to uniqueness of additional small deformation. The problem is still open. It is to be expected that the required necessary and sufficient condition will be of thermodynamic origin and will imply or be equivalent to Baker & Ericksen's conditions. (Added in proof: Noll & Coleman inform me that on the basis of a requirement of elastic stability which generalizes that of Gibbs for fluids, they have solved this problem, showing that the stored energy must be a convex function.)

To describe the finite deflection of a bent and twisted rod, it seemed necessary in the last century to revert to the ideas of the Bernoulli-Euler theory. Saint Venant introduced a mathematical definition of twist of a skew rod (1843); by its aid, Kirchhoff (1859) generalized Euler's three-dimensional theory of bending (1774) so as to include twisting. The strain of the rod is described, in effect, by the angle through which a pre-assigned normal is turned with respect to the binormal. Guided by this idea, Duhem (1893) suggested the general concept of an oriented body, consisting not only of points but also of non-material, independently assignable directions associated with the points. This concept provides easy representation of twisting, anisotropy, internal structure, etc. E. & F. Cosserat (1909) proposed very inclusive theories of rods and shells on this basis. In all this work, the description of strain is intuitive rather than proven. Lacking is the counterpart for oriented bodies of the classical fundamental theorem of strain, namely, a point space is specified to within a rigid motion by its arc length. Ericksen and I have provided such theorems for rods and shells, not only constructing general invariant descriptions of strain but also proving their validity [1958, 3].

It should thus be possible, easily, to construct modern, general theories of shells and rods along the lines explored by the Cosserats. In these theories, the stored energy or the stress and couple resultants of the rod or shell are assumed to be arbitrary functions of the strain measures. The results, conceptually analogous to the Green-Kelvin theory of hyperelasticity or the Cauchy theory of elasticity in three dimensions, will be direct, strictly one- and two-dimensional theories of oriented bodies subject to strain and rotation of any magnitude, the ultimate refinement of the Bernoulli-Euler-Kirchhoff theory. No question of approximation arises.

Meanwhile, the second approach to rods and shells, regarding them as three-dimensional bodies whose behavior is approximated by a one- or two-dimensional theory, has been explored, though not to the same point. The early attempts of Cauchy and Poisson for plates are set within the linear theory, the equations of which are integrated across the thickness of the plate and the results expanded in powers of the thickness. The equilibrium equations, of course, should be exact consequences of the three-dimensional ones. For shells, this was proved by Novozhilov [1943, 1]; more elegantly, by Zerna [1949, 1]. For rods, it should be possible to get the result either by integrating twice the equations for a solid, or by integrating once the equations for a shell, but neither proof has been carried through. A method of power series expansion for the elastic law was sampled by Basset [1890, 1] and worked out in detail by Synge & Chien [1941, 1] [1944, 1]. It is very elaborate and suffers from the defect, mentioned by E. & F. Cosserat (1907), that the confluence of boundary conditions in the limit makes convergence of these series unlikely and their meaning uncertain. Synge & Chien, recognizing the problem of finite deflection, use a three-dimensional stress-strain relation allowing for large rotation but presuming small

strain. It must be emphasized that their theory, apart from all formal and analytic questions, is necessarily a special case of the Cosserats'.

If we suppose the Cosserats' program to have been carried out in all detail, we face a fundamental question in shell theory somewhat analogous to the Saint-Venant problem in torsion. For a three-dimensional shell of elastic material obeying the Green-Kelvin theory of finite hyperelasticity, consider the class of solutions corresponding to all the different stress boundary values which yield the same stress and couple resultants on the edges. At interior points of the middle surface, the stress and couple resultants are determined. To what extent are they given, at all points, by the same functions of the strain measures of a shell? This and its counterpart for rods are the fundamental problems of consistency of the two distinct approaches followed since James Bernoulli's day. Like Saint-Venant's problem, they reduce to establishing and delimiting the continuity of a functional. Consistency may be expected to hold only asymptotically and hence to provide a logical basis for popular perturbation processes. (Added in proof: Consistency of the corresponding problem in the theory of slabs, in the limit of vanishing thickness, has been established by Morgenstern [1959, 31].)

In proposing a theory of initially stressed elastic bodies, Cauchy (1829) was the first to employ a method that has recently proved basic in all sorts of studies of models of matter. Assuming a general linear dependence of the actual stress upon the initial stress and the derivatives of the displacement, he then found the most general form such a relation may have and yet indicate the same material property to all observers. Since observers may be in relative motion, this kind of invariance is independent of coordinate invariance, which Cauchy also investigated. Invariance is the most powerful concept in the hands of the student of mechanics today. It enables him to determine the most general material response that is conceivable within an assumed class. The response of real materials, if of the assumed class, must be included. Cauchy's papers, especially the short notes containing only partly worked-out ideas that he wrote toward the end of his life, contain not only much of what has since gone into tensor analysis and group theory but also many other ideas relevant for study of materials but not yet applied.

An invariant rate of stress was calculated by Zaremba (1903) in the course of arriving at a correct theory of viscoelasticity of the Maxwell type. The general problem of invariance of constitutive equations was first attacked in a remarkable memoir of Oldroyd [1950, 1]. Several other studies used special cases, but an adequate concept was first put forward explicitly in Noll's principle of "isotropy of space" [1955, 3], which could be called more descriptively "material indifference." The physical idea is simply that materials exhibit the same response to all observers; a spring on a rotating table, for example, exerts the same force in response to a given deflection as it does when attached to the earth. This may sound trivial; its import begins to appear when we recall that the laws of dynamics do *not* enjoy this invariance. Material indifference may be linked with D'Alembert's principle, for it asserts that the effective forces of inertia are the *only* ones not specifiable in a form independent of the observer. For the older theories, this principle of material indifference is satisfied automatically, but for rate theories it results in major simplification.

A simple theory of elastic response results by supposing strain rate and stress rate to be related as are stress and strain in classical elasticity, except that the magnitude of the stress has an influence. In proposing this concept of "hypoelasticity" (1953) [1955, 7, 8], I wished to avoid the idea of the "natural" state in the classical theory of finite elastic strain; so as to avoid introducing viscoelastic rate effects, moduli having the dimension of time are excluded. As in my earlier theories of nonlinear fluids (1947 onward), this led to a restricted class of constitutive equations. The tool used for analyzing dimensional invariance is the classical Pi theorem, a simple rigorous proof of which has recently been given by Brand [1957, 1]. Stress-strain relations are obtained by integration and differ, in general, according to the manner in which the specimen is loaded. Following up a special case suggested by T. Y. Thomas [1955, 7] and A. E. Green [1956, 3], I was able to show that hypoelasticity can predict primary yield at a certain finite stress, followed by secondary or von Mises yield for infinite stress [1956, 6]. This phenomenon, a mathematical consequence of the invariance requirements, shows that yield as a proved consequence of a smooth theory of rates, rather than a semiempirical assumption, is a possibility.

Noll showed that every isotropic elastic body is also hypoelastic [1955, 3]. Green and Thomas showed that most of the common theories of plasticity, if corrected so as to satisfy the principle of material indifference, are special cases of hypoelasticity [1955, 7] [1956, 3-4]. Ericksen [1958, 2] and Bernstein & Ericksen [1958, 1] characterized cases in which various definitions of hypoelastic energy lead to a kind of conservation law. Thus hypoelasticity seems to include and unify all of the simpler ideas of purely elastic-plastic behavior. Noll's hygrosteric materials [1955, 3] are more general by virtue of their possible viscoelasticity of Maxwell-Zaremba type. *Cf.* also Cotter & Rivlin [1955, 1].

Meanwhile, Rivlin & Ericksen had formulated a properly invariant viscoelastic theory of Meyer-Voigt type [1955, 5]. While the accelerations of all orders, and their derivatives, as well as the displacement gradients, are taken as the kinematic variables describing the deformation, principles of invariance developed in this remarkable memoir reduce the stress-strain relations to a surprisingly simple and explicit form. Algebraic theorems of Spencer & Rivlin [1959, 4] provide normal forms for theories of isotropic materials in which the stress may depend upon any finite number of symmetric tensors of the second order.

Experimenters are sometimes dismayed at the complications the theorists are nowadays introducing, but the results are in fact increasingly lucid and important if but properly understood. A general argument shows that typical effects of "cross-viscosity," such as the swelling of fluid leaving a tube or the rise of fluid on the inner of a pair of coaxially rotating cylinders, now well known in paints and polymers, are predicted qualitatively by almost any nonlinear theory and hence do not confirm any particular one, not even the attractively simple and relatively general Reiner (1945)-Rivlin (1947) theory. Precise measurements are difficult. From the Rivlin-Ericksen theory it emerges that in all the idealized viscometric problems, all but a few of the possible theoretical terms vanish; hence the apparently infinite variety of models is seen, from theory alone, to reduce, insofar as concerns presently available experimental test, to a few simple alternatives. These cases can be distinguished, at least in part, by universal relations that do not require determination of any material modulus but consist rather in equalities or inequalities connecting the stresses with each other and with kinematic variables. Results of this kind, preliminary to a rational program of experiment, have been marshalled and extended by Markovitz [1957, 3] and Ericksen [1959, 1]; the latter has surveyed also the new results showing that for many materials, steady rectilinear flow is impossible in noncircular tubes.

Perhaps the most natural concept of material behavior is the most general that is consistent with dynamical invariance. A rather general one is as follows: The stress is determined by the entire strain history. For its mathematical formulation, this extremely simple idea, which embraces not only the Rivlin-Ericksen materials but also the Boltzmann-Volterra material with after-effects or memory, requires the theory of

functionals. Such formulations have been given by Noll [1957, 4] [1958, 4] and by Green & Rivlin [1957, 2] [1959, 3]. The advantages from studying so general a material should be obvious; since its properties come close to being properties of matter, observation of such properties by experiment is disqualified as evidence in favor of any particular theory.

In the foregoing, functionals and invariants have several times been mentioned. While the theories of these quantities are little likely to be known by the average engineer, he will recognize at once the simplicity of the ideas they embody and their importance for material behavior. Mathematics can never prove that any physical material is represented by a particular constitutive equation, but it can, and does, prove that many kinds of constitutive equations are impossible for any material, or that a great variety of different notions of material behavior can lead to one and only one common result in some particular experiment. What is simple mathematics depends to a great extent on what one has learned. Huygens deplored the calculus, and Daniel Bernoulli refused to grant physical usefulness to any theory using partial differential equations. These men were far from stupid or ignorant, but their prejudices prevented them from understanding the theories of the catenary and the elastica, in one case, and the theory of travelling waves in the other; while great creators in their youths, they were sterile and reactionary in old age. With them, the case is clear cut, for the mathematics they rejected was suggested in fact by physical problems and was introduced so as to solve them. Nowadays the case is not so clear. While the physical scientist of today is not likely to use much mathematics less than fifty years old, the newer mathematics has been developed mostly in oblivion to physical needs and is put in terms hard to understand. Perhaps the newest studies of materials will close the rift between pure mathematical creation and physical thinking.

So as to achieve a framework broad enough to include continuous materials, the concepts of mechanics were repeatedly re-examined in the eighteenth century. The now common general laws of linear momentum and moment of momentum, formulated by Euler (1752, 1775), furnish only one of the several bases then proposed. Axioms for mechanics including the concept of stress and emphasizing continuous bodies were formulated by Hamel [1908, 1]. Such a set of principles, however, is incomplete: It furnishes us with an empty universe to which we may add materials, but we are not told how. Noll [1957, 4] [1958, 4] perceived that a useful set of laws for mechanics should specify the response of materials as well as their inertial reactions. In his system, the principle of material indifference is an axiom, and the most general mechanical constitutive equation is determined. In contrast to older attempts, Noll's treatment contains only a few axioms but many definite, proved consequences of them.

Purely mechanical phenomena do not exhaust the range of Rational Mechanics, which concerns also the interaction of inertia with energy and electromagnetism. A proof that thermomechanical gross phenomena may result in mean from a purely mechanical molecular model is afforded by Maxwell's kinetic theory of monatomic gases (1867). Guided by results from this theory and by more general ideas, I proposed (1949) as a principle for continuum mechanics what I then called "Brillouin's principle" and now prefer to call "the principle of equipresence": a variable present in one constitutive equation is present in all. This would seem to stir up the effects of deformation and temperature gradient, for example, into thorough confusion, but in fact it does not. Considerations of dimensional, co-ordinate and material invariance reduce drastically the number of possible interactions. For the "Maxwellian fluid" it turns out that in the linear case invariance alone forces the separation of the effects of deformation and temperature gradient that were formerly studied only in separate theories, one mechanical and the other thermal.

Toupin's theory of the elastic dielectric [1956, 5] is an entering wedge toward a rational concept of electro-mechanical interactions. A fully dynamical theory seems to require both a proper extension of the principle of equipresence and a four-dimensional kinematics independent of geometric assumptions regarding space-time. The latter has been provided by Toupin [1958, 5].

The theory of the motion of heterogeneous bodies or coexistent continua begins with Maxwell's kinetic theory of gas mixtures (1867). Guided mainly by this work and somewhat by recent studies in "irreversible thermodynamics," I formulated the general principles of creation for exchange of mass, momentum, energy and entropy, independent of constitutive assumptions but subject to the proviso that entropy is additive [1957, 5].

In the kinetic theory itself, no exact solution except the equilibrium solution was known until recently. For a Maxwellian gas, I had the good luck to hit upon the exact solution for shear flow (1956). The flow has been criticized as artificial; it may be so, but it is the same one as was used by Maxwell for his heuristic explanation of kinetic viscosity (1859) and is a flow discussed unrigorously or incompletely in every elementary treatment of continuum or kinetic theory of a compressible fluid. My solution is valid for all degrees of rarefaction and exhibits a continuous transition from linear viscous response to a stress pattern in which normal or cross-viscous stresses predominate overwhelmingly over shear stress. At a definite value of the truncation number, however, the flow becomes thermally unstable. For this flow, it is possible to calculate the Chapman-Enskog approximations explicitly and to show that they converge for a sufficiently dense gas, but converge only to a special solution. While the Navier-Stokes law emerges as a general asymptotic formula, the "higher approximations" have no such status and furnish no additional correct information, in general. This solution serves as a counter-example to many beliefs about the kinetic theory based on "physical intuition"; it also furnishes an example of possible behavior of a viscoelastic substance of the Maxwell-Zaremba type and a striking contact between the kinetic theory and the modern continuum theories.

Consistency between the kinetic theory and continuum mechanics, apart from constitutive equations, was proved by Maxwell (1867). After a notable prior attempt by Irving & Kirkwood (1950), Noll [1955, 4] succeeded in formulating general definitions of velocity, stress and flux of energy as statistical expectations and in proving that these quantities satisfy exactly the field equations of continuum mechanics. This shows, on the one hand, that the apparently contradictory views of matter as continuous or discrete are in entire agreement on the level of phase averages. On the other hand, it is somewhat disquieting, since the result is not a limit theorem or approximation and is just as valid for one ball in a box as it is for a solid body consisting of billions of molecules. For the ball in the box, what is shown is that the mean transfer of momentum across a plane in many trials of the same experiment is a stress in the sense of continuum mechanics. By the same token this is all that is proved for the billions of molecules, but in the latter case, such a result is not enough. What is needed is some means of identifying phase averages with the results of experiments on a single large body.

For equilibrium, this identification is given by an ergodic theorem of Khinchin (1946); as the number of degrees of freedom grows large, the probability that the time average differs by a finite amount from the phase average approaches zero. For disequilibrated systems, no such statement has been proved or would be appropriate. To find a proper ergodic principle or some other means of interpreting phase averages for deforming bodies is a major open problem of statistical mechanics.

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Analytical Methods in Applied Mechanics

(See also Revs. 600, 601, 608, 624, 625, 642, 659, 704, 799, 837, 890, 965, 1002, 1031, 1088)

593. Altman, M., On the approximate solution of linear algebraic equations, *Bull. Acad. Polon, Sci. Cl. III* **5,** 365–370, 1957.

Given the linear system $Ax = b$ with nonsingular matrix A of order n, and a basis e_i for the space, one can form a sequence of vectors x_ν approximating x by projecting $r_\nu = b - Ax_\nu$ orthogonally upon the vectors Ae_i in cyclic order. The method was described by the reviewer [Principles of numerical analysis, McGraw-Hill, New York, 1953; AMR **7** (1954), Rev. 3095] with a geometric sketch of a proof. Author supplies an analytic proof and points out that with suitable choice of metric the method includes the Gauss-Seidel iteration for the system $A^* Ax = A^* b$.

A. S. Householder, USA

594. Laban, S., A generalized exact method for solving certain problems where the boundary conditions are given (in French), 9th Congrès Inter. Mécan. Appl., Univ. Bruxelles 1957; **5,** 286–301.

A partial, nonhomogeneous differential equation and its boundary conditions are mathematically defined. This equation contains a number of unknown coefficients, which shall be computed in such a way that the solution of the problem will be exact.

The assumed function $\psi = K \cdot \bar{U}_1^p \cdot \bar{U}_2^q \cdot \ldots \cdot \bar{U}_i^s \ldots \bar{U}_n^t$ consists of an unknown constant K, multiplied by several functions of the type $\bar{U}_i^s$, where s is an integer exponent, and $\bar{U}_i$ is a polynomial of the same form as that function which describes a corresponding part of a boundary line. This is required in order that the boundary conditions may be fulfilled.

Inserting this assumed function in the differential equation and putting all coefficients of the same variable equal to zero, a system of equations is obtained for determining the unknown coefficients.

Numerical examples are given for (a) clamped triangular plate submitted to a variable load, (b) freely supported isosceles triangular plate submitted to a hydrostatic load, (c) triangular asymmetric membrane submitted to hydrostatic load, and (d) a bar of equilateral triangular section submitted to torsion.

Paper contains some misprints, and some identical symbols have unfortunately different meanings.

Reviewer thinks that the method in itself is of interest. He suggests that it is questionable whether it can be used for solving practical problems.

S. T. A. Odman, Sweden

595. Brousse, P., On a class of singular problems in mechanics of solids and fluid dynamics (in French), 9th Congrès Intern. Mecan. Appl., Univ. Bruxelles, 1957; **5,** 63–72.

The solution of the differential equation $\Delta V(x, y) - (k/y)\partial V(x, y)/\partial y = 0$ is investigated in the particular case when a part of the boundary of domain is situated on Ox. This problem, occurring in several branches of applied mechanics (torsion of shafts, axially symmetric potential flow of fluids) is singular, since the coefficient $1/y$ becomes infinite on a part of the boundary. As an application of the theory, the torsion on the circularly grooved shaft is discussed.

J. Barta, Hungary

Book—596. Petrovskii, I. G., Lectures on the theory of integral equations (Translation of the 2nd revised Russian ed. (1951) by H. Kamel and H. Komm), Rochester, N. Y., Graylock Press, 1957, vi + 97 pp. $2.95.

Like most Russian books in applied mathematics this small volume is written in a simple and clear manner. It contains a brief presentation of the Fredholm theorems and the Hilbert-Schmidt theory. Except for the vibrating string no applications are given. See AMR **5** (1952), Rev. 1932 for a more detailed discussion.

H. Parkus, Austria

Book—597. Churchill, R. V., Operational mathematics, 2nd ed., New York, McGraw-Hill Book Company, Inc., 1958, ix + 337 pp. $7.

The use of operational methods in the study of dynamical systems is well established. This book is a second edition of Churchill's "Modern operational mathematics in engineering" published in 1944. Some new topics are introduced, among them servomechanisms, cooling fans, and generalized Fourier transforms. The treatment is rigorous. Book is intended for students of mathematics, engineering, physics, and other sciences. Some material from advanced calculus is included, although some background in the subject is assumed. Book covers Laplace and Fourier transforms, gamma functions, partial fractions, convolution, ordinary and partial differential equations, functions of a complex variable, Green's functions, and Sturm-Liouville systems, with applications to vibrating mechanical systems, electric circuits, servomechanisms, and thermal units. The wave equation is given particular attention. Book closes with an extensive table of Laplace transforms.

In the opinion of the reviewer, this book is one with which every automatic-control engineer and scientist should be familiar. Author has succeeded in selecting the mathematical subjects of primary importance to the expert concerned with the dynamics of physical systems.

R. Oldenburger, USA

Book—598. Schmetterer, L., Introduction to mathematical statistics [Einfuhrung in die Mathematische Statistik], Vienna, Springer-Verlag, 1956, xxii + 405 pp. DM 11.65.

The well-accomplished purpose of this new textbook is to furnish the reader with a thorough background in mathematical statistics. Mathematically inclined statisticians and mathematicians interested in statistics will appreciate the detailed and carefully worded proofs of all theorems; the engineer-user of statistics, on the other hand, might be easily discouraged and exasperated by the rigor of this book written according to the rules of many famous classical textbooks.

Except for A. Linder's book (Basel, 1951), no comprehensive *modern* mathematical book was published in the German language and Professor Schmetterer's work certainly fills this void by its thorough review of the literature up to 1954. Book's popularity probably will be limited in this country, since English textbooks in this field are numerous.

Prerequisites to follow book are mathematical attitude and interest, differential and integral calculus, group theory, matrix theory and analytical geometry. Main headings are probability theory, sampling theories, confidence limits, estimates, test theories, regression and sampling theories of multi-dimensional normal distributions, nonparametric processes, Bayes theorem.

V. G. Szebehely, USA

599. Glansdorff, P., Fluid dynamics deduced from least constraint by means of the variational method of de Donder (in French), *Acad. R. Belg. Bull. Classe Science* (5) **44,** 3, 236–239, 1958.

Author deduces the fundamental equation of fluid dynamics from the least-constraint principle of Gauss by means of a computation procedure described by de Donder in "Invariant theory of the calculus of variations," Paris 1935 (in French). He assumes that in every point of the volume there exists a nonholonomic relation of compatibility between coordinates, stresses, time and spatial derivatives of the velocity up to any order. The time derivative of this relation is combined with the constraint of Gauss by the Lagrange multiplier in a volume integral.

The formula of de Donder gives the desired result with accelerations as the variable quantities.

Author states that he did not use the condition of conservation of mass without giving details of his compatibility formula.

H. J. Schoemaker, Holland

Computing Methods and Computers

(See also Revs. 594, 610, 623, 626, 889, 891, 957, 987)

Book—600. Forsythe, G. E., and Rosenbloom, P. C., Numerical analysis and partial differential equations. Contemporary state of numerical analysis; Linear partial differential equations, New York, John Wiley & Sons, Inc., (Surveys in Applied Mathematics, Vol. 5), 1958, x + 204 pp. $7.50.

Professor Forsythe, in his survey of numerical analysis, views the field as a means of devising and evaluating numerical techniques for employing computers to solve problems, and to study their convergence and errors. He concentrates on recent developments in the field, emphasizing the contributions made by Russian authors and others whose work is not yet fully known in the western world.

Confining his attention to linear differential equations, Professor Rosenbloom deals primarily with advances in the field since 1953, with due reference to older work which provides the essential background. He discusses methods that are applicable to wide classes of equations and in most cases states results in the form of definite theorems for the sake of easy reference.

This monograph, published as part of a five volume series, was prepared under the editorial direction of Applied Mechanics Reviews. Preparation of the material was under the sponsorship of the Office of Naval Research, U. S. Navy. Ed.

601. Muchnik, G. F., New graphic-analytic method for computing temperatures (in Russian), *Teploenergetika* **3**, 6, 57-59, June 1956.

Author presents a modification of the well-known method of finite differences and intends to remove some numerical troubles of this method in some particular cases. Solving the problem of determining the nonsteady temperature in a wall and on its surface, he calculates the temperature in the nth "layer" at the time $(m + 1)\Delta t$ as arithmetical mean of the temperatures of the neighboring "layers" at the time $m\Delta t$. On this basis, he presents a method to determine temperature in a point on the interior of the wall only from the values on its surface.

Theoretical problems concerning convergence of the method are not discussed. K. Rektorys, Czechoslovakia

Book—602. von Neumann, J., The computor and the brain, New Haven, Conn., Yale Univ. Press, 1958, xiv + 82 pp. $3.

This small volume constitutes the last contribution of one of the great scientists of our time, John von Neumann. The material was prepared for delivery at Yale University during the spring of 1956 in the Silliman Lectures series. However, the lectures were never given, due to the increasing severity of the illness which finally took von Neumann's life on February 8, 1957. The subject is one which attracted his interest for a number of years. It is a subject in which he was eminently qualified, by virtue of his great genius and his contributions in the fields of high-speed calculators and the logic of automata. In spite of the preliminary nature of this work, it is destined to become the nucleus of a new field of research which will challenge the minds of men for many years to come—the comparative study of the human brain and man-made automata.

The book is divided in two parts. In part 1 von Neumann discusses the basic principles underlying the design of modern computing machines, both analog and digital. Some of the properties of analog computers receiving special attention are (1) their continuous but approximate method for representing quantitative information, (2) their capacity to obtain valid solutions to many classes of mathematical problems in spite of their limited accuracy, which is, at best, 0.01%, and (3) the use of basic operations more advanced than the four arithmetic operations in some analog calculators such as the "Stieltjes" integral in the differential analyzer. The characteristics of modern electronic digital calculators are discussed in somewhat greater detail. Of special interest for comparison with the human brain are (1) the quantized or "marker" method for representation of information, (2) the conventional basic arithmetic and logical operations used, (3) the organization of the controls of digital calculators, which is governed by strict logical rules and prescribed sequences, (4) the high precision available in these computers, which is approximately 10^{-11} in large-scale computers currently in operation, (5) the organization and capacity of the memory components, (6) the great arithmetic and logical "depth" required for the solution of most problems on digital computers (i. e. the very large number of operations used in sequence), (7) the use of the memory for storing instructions as well as other information, resulting in the capability of digital computers to modify or operate on instructions, and (8) the use of interpretive subroutines or "short codes" for carrying out functions more advanced than the basic operations built into the hardware of a computer. One of the key points made by von Neumann is that the very high precision requirement of digital computers is dictated by the inherent deterioration of accuracy resulting from the very large number, or great "depth," of the mathematical and logical operations used in sequence.

In part 2 von Neumann compares the functioning of the human brain with the operation of a modern computer, bringing out the areas of "similarity and dissimilarity between these two kinds of automata." He begins by describing the known properties of a neuron and the apparent digital character of its mechanism for receiving and transmitting pulses. Some of the more superficial comparisons between the human brain and its man-made counterpart are, (1) *speed*—there is a factor of about 10^4 to 10^6 in favor of the man-made components, (2) *size*—there is a factor of about 10^8 or 10^9 in favor of the human brain (the number of neurons estimated in the central nervous system is $\sim 10^{10}$), (3) *energy dissipation*—there is a factor of 10^6 to 10^9 in favor of the human components, (4) *accuracy*—there is a factor about 10^8 in favor of the artificial componentry.

Looking deeper into the more intrinsic areas of comparison, von Neumann is led to the conclusion that the basic internal language used by the brain is undoubtedly quite different from the mathematical language with which we are acquainted. He arrives at this conclusion primarily on the basis of the argument that the information stored in the brain lacks sufficient accuracy to enable it to carry out mathematical and logical processes in such "depth" as would be required if the language used were based on conventional mathematical symbols. Von Neumann conjectures that the language used by the brain is probably statistical in nature in which correlation processes play an important role. (See the "Perception—A theory of statistical separability in cognitive systems," Cornell Aero. Lab. Inc., Report Nos. VG 1196 G-1, 1958 and 1196 G-2, by F. Rosenblatt.) He concludes the book with the remark: "Thus logics and mathematics in the central nervous system, when received as languages, must structurally be essentially different from those languages to which our common experience refers.

"It also ought to be noted that the language here involved may well correspond to a short code in the sense described earlier, rather than to a complete code: when we talk mathematics, we may be discussing a *secondary* language, built on the *primary* language truly used by the central nervous system. Thus the outward forms of *our* mathematics are not absolutely relevant from the point of view of evaluating what the mathematical or logical language *truly* used by the central nervous system is. However, the above remarks about reliability and logical and arithmetical depth prove that whatever the system is, it cannot fail to differ considerably from what we consciously and explicitly consider as mathematics."

H. Polachek, USA

Book—603. Phister, M., Jr., Logical design of digital computers, New York, John Wiley & Sons, Inc., 1958, xvi + 408 pp. $10.50.

The following quotation (page 11) perfectly characterizes the book:

"As has been mentioned before, it is the duty of the logical designer to fill the void lying between the system analysis, which describes the problem, and the circuit components which must be connected together to solve it. The remainder of this book will be devoted to a discussion of these duties and of the techniques which may be usefully applied in carrying them out."

The technique is Boolean algebra. Its principles are explained in chapters 3 and 4, its applications to memory elements in chapters 5 and 7, to input-output devices in chapter 8, to arithmetic units in chapter 9, to control units in chapter 11. This enumeration gives but a slight idea of the wealth of information contained in the book. Reviewer hopes that its sound but very concise style will challenge a newcomer in its field to master the book entirely.

Regarding the chapters not mentioned above; chapter 1 is introductory, chapter 2 gives a little bit about circuits. Chapter 6 gives a general survey of some methods with which the logical designer can meet the demand of the system designer. Chapter 10 deals with error-detecting and error-correcting codes; chapter 12 is an epilogue. W. H. Muller, Holland

Book—604. Gotlieb, C. C., and Hume, J. N. P., High-speed data processing, New York, McGraw-Hill Book Co., Inc., 1958, xi + 338 pp. $9.50.

In the rapidly expanding areas of high-speed computer applications the reading public is often subjected to publications that reflect the impact of specific programming situations on the author's mind rather than broad study of the extent of the computer field. Reviewer finds it the more refreshing to peruse a treatise that is not only concise but is aimed at the whole spectrum of computer data processing with an authority very clearly born of experience. Authors first introduce the computing machine by taking it through its historical paces and then familiarize the reader with the various types of arithmetic that a computer will digest. Data presentation and processing is from the onset described in terms of internal circuitry but the technical information is so presented that a relative layman can grasp the fundamentals, without undue strain.

Reader is then made familiar with the procedures applied to analysis, flow-charting and actual coding, and examples are given in illustration. Tactics to be adopted for checking out programs and for ascertaining reliabilities and accuracies are set out in detail. Automatic coding techniques are mentioned and are, in reviewer's opinion, rightly subclassified into monitoring, autoassembly and compiler applications. Interpreters and simulators are also discussed.

The book is clearly aimed at all levels of data processing (as contrasted with data reduction: the scientific applications of a computer). Accountancy, payroll administration, utility billing, inventory control, sorting and filing operations are made to pass the reader's review. Advantages and disadvantages of random and sequential access equipment are discussed.

The "hypothetical machine" that authors introduce in their fifth chapter is a synthesis of various commercial machines on the computer market and is well able to handle the demonstration function that the authors have assigned it.

In all, reviewer has found it a thoroughly readable book, clear in style, thoughtful in presentation and eminently suitable for whomsoever wishes to acquaint himself with the basic concepts of commercial computer applications. Paper, binding and illustrations are excellent; the price is reasonable.

E. L. Eichhorn, USA

605. Willis, J., and Hartley, M. G., A cathode-ray tube analogue-to-serial digital converter, *J. Sci. Instrum.* **35,** 6, 197-201, June 1958.

Small fluctuations of the screen equilibrium potential of a cathode-ray tube cause proportionate small fluctuations in the steady secondary emission current arriving at a collector anode. The application of this fluctuation of secondary emission to an analogue-to-serial digital converter is discussed. An investigation of the parameters affecting changes of secondary emission using an electrode on the face of the tube, maintained at an alternating potential, to vary the screen potential is described. The secondary emission is observed as a signal, developed across a resistor between collector and earth, at screen electrode supply frequency, amplitude-modulated by the changes in secondary emission which occur when the screen is scanned by an electron beam.

The effects of electrode potential, electrode width, steady-state collected current, beam focus, bias applied to the collector and accelerating voltage are examined. The results are compared with those predicted from electrolytic tank studies. The variation of output over the screen surface under different operating conditions is discussed. Experiments to determine minimum electrode width and spacing, consistent with the production of a discrete pulse output from each electrode of a pattern, are described.

From authors' summary

606. Nissan, A. H., Kaye, W. G., and Pilling, Diana E., The use of an electronic digital computer in a chemical engineering problem—drying, *Trans. Instn. Chem. Engrs.* **36,** 2, 107-114, Apr. 1958.

Paper presents an account of studies on the use of previously obtained equations to calculate the conditions that would obtain when some of the controlling parameters are altered. The Manchester University Mart I computer was used for this. The physical background to the investigation is described and the precise mathematical formulation of the problem to be solved by means of the computer is also given. The results of the initial hand computation are presented.

A brief description of the computer procedure follows and the results obtained from its use are discussed. The final sections give general comments on the experience gained on the practical aspects of using an electronic digital computer in such a problem.

From authors' summary

607. Lemann, I., The design and construction of small automatic computers with program control at the Dresden Technical College, *Automation and Remote Control* **17,** 1, 1-14, 1957. (Translation of *Automatika i Telemekhanika* **17,** 1, 3-18, Jan. 1956 by Consultants Bureau, Inc., New York, N. Y.)

Article expounds the principles of constructing a small automatic computing machine with program control, developed in the Dresden Technical College. The machine is intended for small mathematical departments. The author notes the advantages of machines of this type over the large computers constructed in England and U. S. A. From authors' summary

608. Schrenk, G., and Whitaker, R. O., An analog method for finding the real and complex roots of higher order polynomial equations, *GM Engng. J.* **5,** 1, 29-34, Jan./Feb./Mar. 1958.

The solution of polynomial equations is a requirement that occurs in various product design problems in industry. These equations appear frequently, for example, in stability studies of control systems for aircraft jet engines. There was an interest in finding an improved method for solution of such equations. An analog method, using commercially available components, was therefore developed. Using this method, it is possible to determine all of the real and complex roots of a polynomial equation to any desired degree of accuracy. The multiplicity of any root and the number of roots in any given region also may be determined. The equation may have either real or complex coefficients. This analog method offers a saving in solution time for polynomial equations. Twelfth-order equations, for example, can be solved in 30 minutes as compared to about three days using hand methods.

From authors' summary

609. Nag, B. R., On the application of an electronic differential analyser for finding the roots of a polynomial, *Indian J. Phys.* **32,** 5, 212–217, May 1958.

A method of finding the roots of a polynomial with real coefficients by an electronic differential analyzer is described. The principle underlying the method is to set up in the analyser a system having a transfer function of which the numerator is the polynomial whose roots are to be obtained. The denominator of the transfer function is a suitably chosen polynomial. Roots of the polynomial are then obtained by determining the frequencies at which the system gives zero output.

From author's summary by B. Langefors, Sweden

Analogies

(See also Revs. 793, 952, 1080)

Book—610. Sutherland, R. L. Engineering systems analysis, Reading, Mass., Addison Wesley Publishing Co., Inc., 1958, xii + 223 pp. $7.50.

Book is a text intended for a college course on systems engineering for junior and senior students. The point of view is that the methods used to treat dynamical systems apply to all major areas of engineering, and should be presented from the universal point of view.

Chapter 1 is concerned with analogies. Author shows how the same mathematical equation may arise in different areas of engineering, the only difference being in the physical interpretation of the variables and constants in the equation. Chapter 2 introduces the student to the dynamic response of second-order systems through a discussion of the mechanical vibrations of systems with one and two degrees of freedom, which the student can readily visualize. This leads logically to the treatment of analogous oscillations in electrical networks, to which chap. 3 is devoted. This is followed by a similar analysis of acoustical systems in chap. 4, which concludes with a table for analogous terms relating to mechanical-translational, mechanical-rotational, electrical and acoustical systems.

In chap. 5 the author shows how a problem in one system is solved by converting to an analogous system, illustrated by the translation of mechanical problems to electrical, with rescaling where indicated to keep the new constants and variables within reasonable physical ranges. Tables are given for the conversion from pounds, inches, seconds to the Giorgi mks system of units. This is followed by examples of mixed systems involving both mechanical and electrical elements, as well as acoustical and mechanical. Mathematical and graphical solutions are presented in dimensionless form. This leads to a discussion of dimensional analysis and the use of models in chap. 6.

In chap. 7 the author digresses to discuss feedback and control, and illustrates the theory with examples of unity feedback. The book concludes with chap. 8 devoted to the principles of analog and digital computing machines.

Although much has been written on the analysis of engineering systems, it is the opinion of the reviewer that no more lucid introduction to the subject exists. The book is well suited to the needs of the engineer, as well as the student, who wishes to become active in the areas of systems and control engineering.

Reviewer feels that the author has shown superb judgment in selecting and presenting topics for this purpose.

R. Oldenburger, USA

611. Geiringer, H., Limit-type singularities in the plane flow of compressible fluids and of perfectly plastic solids (in English), 9th Congres Intern. Mécan. Appl., Univ. Bruxelles, 1957; **2,** 194–196.

Mapping of the manifolds of the independent variables to the manifold of the dependent variables is a well-known and attractive method of mathematical physics used in problems where the number (n) of dependent and independent variables is the same. The three significant examples for $n = 2$ are the steady plane irrotational compressible flow, the unsteady one-dimensional compressible flow, and the plane perfect plasticity stress problem.

Paper shows the analogy between the first and third examples by using polar coordinates for the velocity vector in the first case and the mean principal stress and the principal direction in the third. The plane corresponding to the hodograph of the flow problem is the stress plane of the plasticity problem. The characteristic lines are the Mach lines and the slip lines respectively. Three sets of limit lines are obtained, one set representing the sonic line and the envelope of the Mohr circles, respectively.

V. G. Szebehely, USA

612. Hay, N., and Markland, E., The determination of the discharge over weirs by the electrolytic tank, *Proc. Instn. Civ. Engrs.* **10,** Pap. 6245, 28 pp., May 1958.

An investigation of the discharge of an ideal fluid over vertical sharp-crested weirs has been made using an electrolytic tank in which an electric field is set up analogous to the desired hydrodynamic field. The shapes of the free boundaries, i.e. the upper and lower nappes, have been obtained for weir heights in the range $0 \leqslant h_w/p \leqslant 1$ where h_w denotes the head on the weir and p the height of the weir above the bed of the approach channel. The electrical solutions are interpreted to give pressure and velocity distributions throughout the hydrodynamic field of flow, and coefficients of discharge are derived.

The shapes of the nappes correspond closely to experimental results for the case of the infinitely deep weir; but as h_w/p increases towards unity, experimental results diverge from the ideal solutions, the divergence being due to friction which has the effect of lowering the nappes. Coefficients of discharge, however, remain comparatively unaffected.

Paper includes an account of the calibration of the electrolytic tank by tests on a model representing discharge through a slot at the end of a channel (for which an analytical solution is known), and the discharge over a free overfall (for which an analytical solution is known), and the discharge over a free overfall (for which a previous numerical solution is available for comparison).

From authors' summary

613. Uvarov, B. A., Approximate method for modeling thermal and dynamic processes for gas-turbine blades (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 9, 39–47, Sept. 1956.

Kinematics, Rigid Dynamics and Oscillations

(See also Revs. 610, 710)

614. Gopp, A. Yu., Approximate methods of investigating oscillations in complicated autonomous systems (in Russian), Kolebaniya v turbomaschinax., Moscow, Akad. Nauk SSSR, 1956, 179–190; *Ref. Zh. Mekh.* no. 4, 1957, Rev. 3904.

Examination of an autonomous link system of n concentrated masses during the oscillations of which forces of external and internal friction occur, assumed small compared with the restoring forces.

When oscillations of this system are linear and describe differential equations of the form

$$m\ddot{x}_j + \Lambda_j\dot{x}_j + \Lambda_{j-1,j}(\dot{x}_j - \dot{x}_{j-1}) + \Lambda_{j,j+1}(\dot{x}_j - \dot{x}_{j+1}) + k_{j-1,j}(x_j - x_{j-1}) + k_{j,j+1}(x_j - x_{j+1}) = 0 \quad (j = 1, \ldots, n),$$

an approximate method for determining the roots of the characteristic equation having an accuracy up to the square of a certain small parameter is recommended. This method leads to the calculation of the real roots of the equation and to the subsequent calculation

arrangement which does not require development of the determinants.

On the basis of this method of investigating linear oscillations, a general means for the approximate calculation of the main vibration characteristics (frequencies and dampings) is described for the case when the oscillations of the autonomous link system with small friction are nonlinear. I. M. Volk

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

615. Filippov, A. P., Induced oscillations of linear systems when passing through resonance (in Russian), Kolebaniya v turbomaschinax., Moscow, Akad. Nauk SSSR, 1956, 5–20; *Ref. Zh. Mekh.* no. 4, 1957, Rev. 3913.

A solution is given of the problem of the passage through resonance of a linear system with one or with any number of degrees of freedom; the calculations are brought to tabulated functions.

For a system with one degree of freedom, the equation

$$\frac{d^2y}{dt^2} + \mu\frac{dy}{dt} + \omega^2 y = \frac{H}{M}\cos\left(\frac{\alpha t^2}{2} + \gamma_0\right) \qquad [1]$$

is examined, where μ, H, M, c and α are constants, $\omega^2 = c/M$.

In initial conditions $y(0) = y'(0) = 0$, the solution of equation [1] is reduced to Fresnel integrals connected with Bessel functions.

In addition, an examination is made of the passage through resonance at variable amplitude of the disturbing force.

Yu. A. Mitropol'skii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

616. Macagno, E. O., and Landweber, L., Irrotational motion of the liquid surrounding a vibrating ellipsoid of revolution, *J. Ship Res.* **2,** 1, 37–49, June 1958.

Authors investigate such irrotational movements of liquids, which are incompressible and free from friction, in the neighborhood of a prolate ellipsoid of revolution as are produced by a vibration of this ellipsoid. The article is concerned only with vibrations whose amplitudes are sufficiently small in every point of the surface of the ellipsoid of revolution.

The kinetic energy of the liquid is calculated with the help of the known potential function of the movement of a frictionless and incompressible liquid surrounding a prolate ellipsoid of revolution which moves in this liquid. The calculations are referred to a "half-submerged ellipsoid" and carried out for various velocity distributions on its surface and for various locations of the nodes, and also for various shapes of the amplitude curve. The results of the calculations for three special cases of the vertical vibration of the "half-submerged ellipsoid" are compared with those of the "strip" theory. The results of the calculation are shown in graphs. M. Strscheletsky, Germany

617. Mitropol'skii, Yu. A., Nonsteady processes in nonlinear oscillatory systems (in Russian), Trudĭ 3-go Vses. matem. s'ezda. Moscow, Akad. Nauk SSSR, 1956, **1**; p. 224; *Ref. Zh. Mekh.* no. 4, 1957, Rev. 3910.

618. Kotov, V. F., The principles of analytical mechanics for systems of variable mass (in Russian), *Uch. zap. Gor'kovsk. in-ta* no. 28, 42–55, 1955; *Ref. Zh. Mekh.* no. 4, 1957, Rev. 3867.

619. Arzhanykh, I. S., The structure of the displacement vector in boundary problems of the dynamics of an elastic body (in Russian), *Trudĭ Sredneaz. in-ta* no. 66, 3–20, 1956; *Ref. Zh. Mekh.* no. 3, 1957, Rev. 3432.

620. Kuznetsov, N. I., Theory of the rotational movement of a nonsymmetrical gyroscope and its application to the study of the rotational movement of a nonsymmetrical projectile (in Russian), Avtoref. diss. kand. fiz.-matem. nauk., Belorus. in-ta, Minsk, 1956; *Ref. Zh. Mekh.* no. 4, 1957, Rev. 3892.

Instrumentation and Automatic Control

(See also Revs. 602, 609, 610, 620, 931, 937, 1019, 1025)

Book—621. Smith, O. J. M., Feedback control systems, New York, McGraw-Hill Book Co., Inc., 1958, xviii + 694 pp. $13.50.

Volume is devoted to a comprehensive treatment of the mathematical theory of feedback control systems. It is divided into four major parts, namely, linear analysis, linear synthesis, steady-state nonlinear analysis, and nonlinear synthesis. Fourier and Laplace transforms, Nyquist and Bode plots, poles and zeros, responses to all kinds of disturbances, minimum phase networks, Routh's stability criterion, power density spectra and correlation functions are covered in part 1. These topics are important for the mathematical analysis of given single- and multiple-loop systems. In part 2, author is primarily concerned with the design of feedback loops to attain desired performance. In this portion of the book he discusses factors which must be considered in design, such as criteria for optimum response and the effect of noise. Root locus, frequency response, compensation techniques, and predictors are covered. This is followed by a discussion of distributed lag systems, including the author's compensation for pure delays by the use of predictor feedback loops.

Part 3 concerns frequency response and phase plane analysis of relays and the analysis of unilateral and bilateral nonlinearities. In part 4, author considers the use of nonlinear controllers or predictors to yield optimum transients for systems subject to limitations of power saturation. The phase plane is employed to explain the role of switching functions. The book closes with a discussion of carriers for the transmission of information in control systems.

The book contains numerous problems and references of value to the student in advanced servomechanism courses for which this volume can serve as a text.

Reviewer feels that this book should be in the library of every servomechanism engineer. The reader will find many important contributions to the science of automatic control written up for the first time in book form. R. Oldenburger, USA

622. Berezin, S. Ya., Improving the dynamic properties of automatic control systems by employing aperiodic feedbacks (in Russian), *Avtomatika i Telemekhanika* **18,** 3, 229–239, Mar. 1957.

Book—623. Cosgriff, R. L., Nonlinear control systems, New York, McGraw-Hill Book Co., Inc., 1958, viii + 328 pp. $9.

This book is particularly timely in view of the increasing emphasis on nonlinear control systems. The texts on nonlinear mechanics used to train control engineers and scientists have been inadequate, in that they have not been written from the viewpoint of the control engineer.

Chapter 1 is devoted to a discussion of open and closed loop systems, described by linear and nonlinear operators. In chapters 2 and 3 the Routh and Nyquist stability criteria, frequency, step, and impulse responses, equalization, and other aspects of linear system analysis are developed, with applications to a-c servomechanisms, regulators, and tachometer feedback. Chapter 4 concerns the linearization of nonlinear systems for small signals. This theory is extended in chap. 5 to the use of linear techniques for the analysis of nonlinear systems subject to signals that are not small. Piecewise linear approximations to nonlinear functions are employed, and the linearization of relay servomechanisms by the introduction of a sinusoidal signal, as well as the use of dither to reduce the effects of nonlinear friction. Backlash is given as an example of a discontinuous type of nonlinearity.

In chap. 6 the phase plane approach is applied to the study of trajectories and the technique is applied to the discontinuous types of nonlinearities mentioned above. Chapters 7, 8 and 9 are devoted to the frequency response of nonlinear systems, with emphasis on describing functions. The reduction of nonlinear differential equations to linear equations with periodic coefficients, the solutions of Hill's and Mathieu's equations for transient response, the stability of periodic solutions, and the response of sampled data systems characterized by linear differential equations with time varying parameters are treated in detail. Chapter 10 concerns the application of statistical methods to determine the response of linear and nonlinear systems to random inputs.

The use of Boolean algebra in digital control elements is covered in chap. 11.

Throughout the book the theory is illustrated by carefully chosen examples, and many problems for student homework assignment are included.

In the opinion of the reviewer the author has succeeded in selecting the topics from nonlinear control theory that are of prime importance to the control engineer, and has presented his material in such a way that the book should be of great value to both the beginner and the automatic control expert.

R. Oldenburger, USA

624. Shinbrot, M., Optimization of time-varying linear systems with nonstationary inputs, *Trans. ASME* **80,** 2, 457–462, Feb. 1958

A method is presented for solving integral equation which arises in problems of optimizing a system with nonstationary inputs. Method applies when correlation functions $\phi_{mm}(t_1, t_2)$ and $\phi_{m\mu}(t_1, t_2)$ can be factored into the forms $\sum_\rho a_\rho(t_1) b_\rho(t_2)$ and $\sum_\rho c_\rho(t_1) b_\rho(t_2)$, respectively, for $t_1 \geq t_2$ (m = message input, μ desired output, t_1, t_2 two instants of time), and when all noise inputs are "white noise" independent of messages. Method is generalized to multi-input systems by use of matrix notation.

Application of method to design of optimum system is shown by two examples. In second example, optimum time-varying filter designed by author's method is compared with optimum time-invariant filter designed by Wiener's method. Difference arises from fact that when the two filters are switched on, author's time-varying filter is optimum from the very beginning, whereas Wiener's time-invariant filter only becomes optimum as its initial transient dies out.

T. P. Goodman, USA

625. Mori, M., Statistical treatment of sampled-data control systems for actual random inputs, *Trans. ASME* **80,** 2, 444–450, Feb. 1958.

Formulas for mean-square errors in a sampled-data control system with random inputs are derived by use of correlation functions of time series, pulse spectral densities, and modified z-transforms. Examples show how mean-square-error formulas can be used to evaluate alternative system designs. In particular, example shows that a sampled-data system giving optimum response to a pulse or ramp input may not be optimum for an actual random input composed mainly of low frequencies.

T. P. Goodman, USA

626. Kogan, B. Ya., Procedure for composing and solving problems with electronic simulators, *Automation and Remote Control* **17,** 1, 31–48, 1957. (Translation of *Avtomatika i Telemekhanika* **17,** 1, 36–52, Jan. 1956 by Consultants Bureau, Inc., New York, N. Y.)

Article develops the procedure for solving linear and nonlinear problems of automatic regulation with electronic d-c simulators. Results are given for the solution of a series of problems on an installation of the ESU-5 type.

From author's summary

627. Stout, T. M., Mathematical relationships for computer control systems, ASME Semiann. Meet., Detroit, Mich., June 1958. Pap. 58-SA-59, 35 pp.

Author presents a survey of ideas for the possible control of processes by means of computers. The paper expresses constraints, objectives and equations between variables in mathematical forms. No new ideas are given in the paper and the content can be easily followed without the knowledge of higher mathematics.

P. P. Bitinger, Canada

628. Minard, R. A., Solids and liquids blended for continuous control of viscosity, *Automation* **5,** 9, 61–63, Sept. 1957.

An increased number of continuous manufacturing processes involving fluid flow are being designed. It is often found that control of the viscosity of the fluid is too critical to be left to the vacillations of chance. An answer to such a problem is described in this article dealing with an instrument control system.

From author's summary

629. Kartvelishvili, N. A., Stability of stationary conditions of hydroelectric power plants having combined derivation and offtakes (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 1, 44–47, Jan. 1957.

630. Birmingham, H. P., and Taylor, F. V., Why quickening works, ASME-ARS Joint Aviation Conf., Dallas, Texas, Mar. 1958, Pap. 58-AV-9, 5 pp.

Quickening has been defined as any modification to a closed-loop man-machine control system which reduces the need for the human operator to perform analog differentiations or separately to sense and utilize derivative information. Therefore, if a system is fully quickened and unburdened (in a fully "unburdened" system, it is unnecessary for the human operator to perform integration), the requirements of system performance will be satisfied if the human operator performs as a simple amplifier. A more complete discussion of quickening is included in reference (2).

The results of several studies indicate the effectiveness of quickening techniques in improving the performance of man-machine control systems. These improvements range from 40% to as high as 10 to 1. It is the purpose of this paper to discuss the reasons for this improvement.

From authors' summary

Tables, Charts, Dictionaries, etc.

Book—631. Dwight, H. B., Mathematical tables of elementary and some higher mathematical functions, second revised edition, New York, Dover Publications, 1958, 217 pp. + index. $1.75 (Paperbound).

Book—632. Camm, F. J., Mathematical tables and formulae, New York, Philosophical Library, Inc., 1958, 144 pp. $2.75.

This British book was "especially compiled for the use of students and those preparing for examinations." Its mathematical, physical, and engineering tables and formulas are, however, presented in a disconcertingly random fashion. The precisionist can object to some definitions, as the ampere "is the practical unit of strength of current, or velocity. It is often described as the measure of current density." More widespread use of the sign $\doteq$ would assist the user in use of approximations, for many of which the limits are not stated. Line drawings are used too sparingly and more would enhance the usefulness of the tables. Finally, although this is a 6th printing in 1958, the table of elements stops at uranium. Nevertheless, there are nuggets of information rarely seen in books of this character: rule for numerical extraction of cube root; table of Euler's numbers; conversion of fractional inches to millimeters; and conversion factors expressed as rational fractions for slide rule use. Indeed, the tables will be most useful to the person for whom little more than slide rule accuracy suffices.

V. Salmon, USA

Elasticity

(See also Revs. 595, 619, 647, 650, 655, 671, 676, 697, 698, 711)

Book—633. Goodier, J. N., and Hodge, P. G., Jr., Elasticity and plasticity. The mathematical theory of elasticity; Mathematical theory of plasticity, New York, John Wiley and Sons, Inc. (Surveys in Applied Mathematics, Vol. I), 1958, ix + 152 pp. $6.25.

The authors' principal aim is to draw attention to significant recent developments in the mathematical theories of elasticity and plasticity, concentrating on the modern trends in analysis. Emphasis is on contributions made by Russian authors and others whose work is not yet fully integrated into the western literature.

This monograph, published as part of a five volume series, was prepared under the editorial direction of Applied Mechanics Reviews. Preparation of the material was under the sponsorship of the Office of Naval Research, U. S. Navy. Ed.

634. Levshin, V. A., An application of toroidal coordinates in the theory of elasticity (in Russian), *Nauchn.-tr- Mosk. tekhnol-in-ta legkoi prom-sti* no. 7, 260–283, 1956; *Ref. Zh. Mekh.* no. 4, 1957, Rev. 4561.

Author discusses the application of toroidal coordinates for the solution of the problem of the equilibrium of an elastic body. The solution is given by Papkovich-Neuberg harmonic functions. In the case of axially symmetrical loading of the torus, one harmonic solution remains. The general expression for this contains toroidal functions introduced by Neiman. Paper does not contain any concrete examples of the calculation.

It should be noted that the basic results of this paper are contained in a paper by A. F. Zakharevich [*Zap. Leningr. gorn. in-ta* **26,** no. 1, 1952], where the apparatus described above is used for solving the problem of stresses in a rotating torus.

V. K. Prokopov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

635. Sokolov, N. B., On the equations linking stresses and large deformations in a plane deformation condition (in Russian), *Trudi Penzensk. Industr. In-ta* no. 3, 14–23, 1956; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5858.

A plane deformation condition is examined. The components of a finite deformation are expressed through the displacement function. The principal elongations and directions of the principal axes before and after deformation are determined. By introducing auxiliary values a clear expression is obtained of the stress components through the generalized components of deformation. From the expressions obtained, the formulas of Juk and Khenk can be arrived at for small elastic and small elastic-plastic deformations. The link between stresses and deformations can be obtained with the cooperation of the coefficients of plane extension of the edge projection after deformation in comparison with the original edge plane by substitution of the deformation components by these coefficients. The dependence of the value of the tengential stress on the spatial deformation is established. V. G. Osipov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

636. Poynor, J. F., Dead-weight stresses in piping systems and their inclusion in thermal stress analyses, Instn. Mech. Engrs., Preprint, 17 pp., 1958.

The existing methods of stress analysis for piping systems have dealt only with thermal expansions. Author has found that these methods are inadequate in the cases of high-temperature large bore piping as found in modern oil refineries, and that the stresses due to dead weight (own weight of piping) must also be taken into account. Extending the Meyer-Hovgaard and grapho-analytical methods, author develops his own method for computing the combined dead-weight and thermal stresses. He presents the general theory and applies it to special cases, like uniform loading over a straight or curved section, concentrated vertical loads, uniformly distributed load over a 90° arc.

In order to aid the user he computes and tabulates values of various terms and expressions in his formulas. An example illustrates how to use those tables, but even with the tables the method is not very simple. T. Leser, USA

637. Votinov, M. P., and Kuvshinskii, E. V., Thermoelastic phenomena in SKS-30A and SKB rubbers in adiabatic deformation up to the breaking point, *Soviet Phys.-Tech. Phys.* **2,** 10, 2139–2142, June 1958. [Translated from *Zh. Tekh. Fiz., Akad. Nauk SSSR* **27,** 6, 2303–2307, Oct. 1957 by Amer. Inst. Phys., Inc., New York, N. Y.]

The thermal states of bodies such as rubber change considerably on deformation. Extension (by 300–350%) and compression of noncrystallizing rubbers are accompanied by evolution and absorption of heat appropriate to the work of deformation. This is a direct indication that the elastic forces are kinetic in nature. The nature of the elasticity and the state of the material at large (nondestructive) extensions can be elucidated by studying the transformation of work into heat on adiabatic deformation.

Thermoelastic phenomena were studied during deformation to breaking point in unfilled and filled SKS-30A and SKB rubbers. The rubbers were prepared at the S. V. Lebedev All-Union Synthetic Rubber Research Institute. They differed in the vulcanization time (+138 C). The times (in minutes) are given on the curves in the experimental section.

Before measurement the specimens had not been deformed or treated in any way. During measurements they were extended at 100% per second to breaking point. The methods of measurement, of working up the data, and the experimental setup have been described in previous papers. From authors' summary

638. Votinov, M. P., Sul'zhenko, L. L., and Kuvshinskii, E. V., Thermoelastic phenomena in rubbers based on natural latex during cyclic deformation, *Soviet Phys.-Tech. Phys.* **2,** 10, 2143–2148, June 1958. [Translated from *Zh. Tekh. Fiz., Akad. Nauk SSSR* **27,** 6, 2307–2313, Oct. 1957 by Amer. Inst. Phys., Inc., New York, N. Y.]

The thermoelastic phenomena in rubbers based on natural latex have been investigated in extension during extension-contraction cycles. The deformation rate was 100% per second. The rubbers differed in vulcanization conditions and nature of the dispersed filter.

Heat equivalent to the work of extension is shown to be generated in the first stages of extension. Further deformation causes excess heat (related to crystallization) to be generated reversibly.

The onset of crystallization depends on the vulcanization conditions and nature of the dispersed filler.

From authors' summary

639. Langer, B. F., Design values for thermal stress in ductile materials, ASME-AWS Joint Metals Engng. Conf., St. Louis, Mo., Apr. 1958. Pap. 58-MET-1, 12 pp.

A fundamental difference between thermal and mechanical stresses is that yielding produces relaxation of the thermal stress. Therefore it follows that the methods used for safety evaluation of load stresses should not be applied to the calculated values of thermal stress. In this paper, methods are proposed for the application of strain-cycling data to practical design problems involving thermal stress. The subjects considered include multiaxial stress conditions, combined steady and alternating stress, and cumulative damage. It is shown that when the calculated thermal stress exceeds the yield stress of a ductile material, some of the commonly used concepts, such as the Soderberg diagram, must be modi-

fied. The design methods proposed constitute safe approximations which are consistent with the experimental data available.

From author's summary

640. Manson, S. S., Thermal stress, Part I: Appraisal of brittle materials; Part II: Quantitative techniques for brittle materials, *Mach. Design* **30,** 12, 114–122, June 12, 1958; **30,** 13, 99–103, June 26, 1958.

641. Kylpin, A. A., Stress determination in a cylinder by means of experimental temperature measurements (in Russian), *Teploenergetika* **4,** 1, 33–35, Jan. 1957.

642. Broshko, M., Equations of the mechanics of inelastic bodies (in Russian), *Byul. Pol'skii Akad. Nauk, Otd.* (4) **2,** 3, 123–126, 1954; *Ref. Zh. Mekh.* no. 4, 1957, Rev. 4765.

The connection between the basic equations of the theory of elasticity and the equations of laminar flow in liquids enables author to assume the existence of such a connection between the equations of the mechanics of inelastic bodies and those of turbulent motion. In order to verify the correctness of such an assumption author examines the results of experiments carried out by Grübler with concrete test samples subjected to shear loading [M. Grübler, *Z. VDI,* **53,** p. 449, 1909]. M. M. Manukyan

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

643. Kozhevnikova, M. K., and Novozhilov, V. V., Approximate theory of the restrained torsion of closed thin-walled rods accounting for distorsions in the cross sections (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 9, 72–83, Sept. 1956.

Authors discuss the torsion of slender thin-walled rods loaded by two twisting moments acting on the ends which are stiffened by two absolutely rigid diaphragms. There are two simplifying assumptions. First, the distribution of axial stresses during restrained torsion is analogous to the shape of deplanation when the torsion is free; second, the influence of longitudinal bending moment and twisting moment (in contrast to transverse bending moment) may be neglected. The displacements and stresses are given in a closed form.

Paper is a simplified version of a solution given by the authors and I. A. Lashmanova in their previous work entitled "Restrained torsion of tubes," *Uchen. Zap.* LOLGU, 1956.

M. Sokolowski, Poland

Viscoelasticity

644. Papsdorf, W., and Schwier, F., Creep and tension loss of steel wire, particularly at slightly elevated temperatures (in German), *Stahl u. Eisen* **78,** 14, 937–947, July 1958.

Paper covers these points: Methods of carrying out creep tests; findings gained up to present concerning creep and tension loss of steel wire; theory of the creep process; manner of carrying out the tests; results of creep tests at different temperatures; changes in the physical properties after creep tests.

From authors' summary

645. Jenkins, W. D., and Johnson, C. R., Creep of annealed nickel-copper, and two nickel-copper alloys, *J. Res. Nat. Bur. Stands.* **60,** 3, 173–191, Mar. 1958.

Creep tests were made in tension under constant loads at temperatures of 300, 700, and 900 F on initially annealed specimens of nickel, copper, and 70-percent-nickel–30-percent-copper and 30 percent-nickel–70-percent-copper alloys. Tests at 1200 F were also made on the nickel and the two alloys, but not on the annealed copper, as the resistance to creep of copper is relatively low at this temperature. The investigation included a study of the influence of rate of loading on the creep stress and of prior thermal-mechanical history on the creep behavior of the alloys at several selected temperatures. Contour and hardness surveys and metallographic examinations were also carried out on some of the fractured specimens to ascertain the effect of creep on the necking characteristics, hardnesses, and structures of the metals.

From authors' summary

646. Fluck, P. G., and Washa, G. W., Creep of plain and reinforced concrete, *J. Amer. Concr. Inst.* **29,** 10, 879–895, Apr. 1958.

Authors have reviewed English literature on laboratory and field tests of creep of concrete. Rather than abstract each article, they present a general discussion of information regarding the creep behavior and the factors influencing such behavior of plain and reinforced concrete.

A list of 121 references is provided; 25 of these are specifically cited in the paper, but all have been considered in its preparation. This summary of published test results is intended for the general reader and may serve as a starting point for those who wish to continue study of this subject. From authors' summary

647. Ross, A. D. Creep of concrete under variable stress, *J. Amer. Concr. Inst.* **29,** 9, 739–758, Mar. 1958.

Creep has important effects on the stresses and deflections of reinforced and prestressed structures. Concrete structures in use are subject to variable stress whereas most of the data on creep have been obtained under constant stress. It is therefore desirable to be able to compute creep under variable stress from the results under constant stress.

Three methods for doing this are discussed and experiments designed to test these methods are described. Each method has a certain advantage in particular circumstances, depending on the character of the stress variation, the extent of creep data available, and the accuracy required. From author's summary

648. Final report on investigations conducted at the Polytechnic Institute of Brooklyn on stresses in structural elements in the presence of creep, AFOSR TR 58–12 (Polyt. Inst. Brooklyn Aero. Lab. Rep. 418; ASTIA AD 148092), 7 pp., Jan. 1958.

649. Erickson, B., Patel, S. A., and Hoff, N. J., Experimental investigation of clamped circular plates subjected to rapid creep, AFOSR TN 58–51 (Polyt. Inst. Brooklyn Aero. Lab. Rep. 411; ASTIA AD 148093), 8 pp. + 2 figs., July 1957.

Twenty-one clamped circular plates were tested at an elevated temperature under uniform lateral pressure. The plates were 12 in. in diameter and were made of 5052-0 aluminum alloy sheet. Sheet thicknesses of 0.032, 0.040, 0.051 and 0.064 in. were used. The plates were maintained at 500°F in an oven and were subjected to constant uniform lateral pressure. The lateral deflection of the center of the plate was measured in each test. Curves showing the change in deflection with time are presented in the report.

From authors' summary

650. Arutyunyan, N. Kh., and Chobanyan, K. S., Torsion and bending of prismatic rods made of different materials while taking into account the effect of creep (in Russian), Trudí 3-go Vses. Matem. S'ezda. Moscow, Akad. Nauk. SSSR, 1956; **1,** p. 199; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5976.

651. Boguslavskii, P. Ya., On creep due to torsion (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 4, p. 151–152, Apr. 1956.

Plasticity

(See also Revs. 611, 633, 731, 733, 735)

Book—652. Cristescu, N., Dynamic problems in the theory of plasticity [Probleme dinamice in Teoria Plasticitatii], Bucarest, Academia Republicii Populare Romine, 1958, 247 pp.

Book represents an elaboration of a course of lectures to students of physics and mathematics in their fourth (i.e., final) year at Bucharest University. It is remarkable that the subject should be offered to undergraduates. Chapter headings and paragraph numbers give an indication of the topics treated and of author's emphasis: Introduction (§1–4): Concepts of plasticity therory; I (§1–9): Propagation of plastic waves in semi-infinite bars; II (§1–2): Influence of the rate of deformation; III (§1–6): Shock waves in solids; IV (§1–4): The finite bar; V (§1–5): The propagation of plastic waves in bars with variable elasticity (e.g. strain-hardening material); VI (§1–6): Propagation of disturbances in flexible threads; VII (§1–4): Other problems (topics include waves in thick bars, in plates, and spherical waves).

The numerous (261) references to books and original papers attest to author's thoroughness. Discussion is lucid and the ratio of text to mathematical matter is well chosen. The book does not lay claim to intrinsic originality; rather, it is a survey of recent published work in the field, and in this sense it is excellent. Production is cheap paperback. F. C. Roesler, England

653. Eason, G., Velocity fields for circular plates with the von Mises yield condition, *J. Mech. Phys. Solids* **6,** 3, 231–235, May 1958.

Hopkins and co-workers discussed the load-carrying capacities of this problem, obtaining stress fields. Author obtains velocity fields associating them with the stress fields. The resulting equations are suitable for numerical integration. Graphs of results are given for certain cases. L. Villena, Spain

Book—654. Geleji, A., Computation of forces and power in plastic forming metals [Die Berechnung der Kräfte und des Arbeitsbedarfs bei der Formgebung im bildsamen Zustande der Metalle], 2nd revised and enlarged ed., Budapest, Akademiai Kiado, 1955, 415 pp.

Book is a revision of author's 1948 edition of the same title. The essential chapters are on various phases of rolling as well as drawing operations for rods, wires, and tubes, combinations of cold-drawing and cold-rolling, extrusions and the bending and deep-drawing of sheetmetal. The comprehensive treatment of experimental results and design information is based on the 208 references listed in the text. Chapter I is a brief review of total strain theory which is used to establish the design equations found throughout the book. Although author states that the book is primarily for use by machine and tool designers, it is regrettable that he did not include the slipline solutions or incremental strain solutions of the many papers published during the past years on experimental and theoretical work in the field of plasticity.

J. Frisch, USA

655. Hutchison, M. M., and Louat, N., The effect of preloading on the yield point in iron, *Australia, Melbourne, Aero. Res. Lab., Rep. Met.* 27, 12 pp. + 4 figs., Nov. 1957.

Measurements of the increase in yield stress in iron caused by preloading below the yield point have been carried out with a view to distinguishing between current theories of the yield point in Cottrell-locked systems. The results obtained tend to favor a theory based on a model in which prior to yielding the dislocations move significantly carrying their atmospheres with them.

From authors' summary

656. Ivlev, D. D., Loss of strength of rotating near-circular disks (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 1, 141–144, Jan. 1957.

The change in shape of the plastic region in the rotating thin disk due to small variation of its circular outline is investigated. The solution, restricted to the first approximation, is based on the continuous dependence of the stress field on the outline shape of the disk. It is shown that under certain conditions the form of the plastic region may be considerably affected.

K. Julis, Czechoslovakia

657. Malyavinskii, N. A., Approximate method of solving problems of the plastic limit of a plane-deformed medium (in Russian), *Sb. naucb. tr. Tonskii elektromekh. in-ta inzh. zh.-d. transp.* **22,** 76–101, 1956; *Ref. Zh. Mekh.* no. 4, 1957, Rev. 4706.

The idea put forward by S. A. Khristianovich [*Prikl. Mat. Mekh.* **11,** no. 2, 1947] for an approximate integration of the equations of a supersonic flow of gas by means of approximation of the variable coefficient, entering into these equations, of some function, at which they possess a form capable of integration, was made use of by V. V. Sokolovskii ["Theory of plasticity," GTTI, 1952] for the equations of plane deformation of an ideally plastic body. Using this method, author examines the problems of compression of a plastic strip by a plane or wedge-shaped die (in the latter case it is assumed that there is no extrusion). In the case of the plane die the solution is carried to the point of numerical results and proved to be close to Sokolovskii's results, obtained by means of numerical integration. G. S. Shapiro

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

658. Davydov, V. I., Tangential stresses in plastic bending (in Russian), *Trudi Gor'kovsk. politekhn. in-ta* **11,** 3, p. 4960, 1956; *Ref. Zh. Mekh.* no. 4, 1957, Rev. 4734.

The distribution is investigated of the tangential stresses occurring during the transverse deflection of a beam of rectangular section for the case when the tension-compression curve of the material of the beam is delineated by two inclined straight lines, that is to say, a case of linear consolidation.

The solution takes an approximate form in the sense that the hypothesis of plane sections is conserved both in the case of the presence of tangential sections and that of transverse sections. To calculate normal stresses in the same section a start is made from the case of single axis stressed condition, etc.; therefore for the particular case of an ideal plastic material, tangential stresses are only found within the limits of the elastic zone.

The bibliography and sources of information are not referred to in the paper and apparently author is unaware that the questions raised in the paper have been very fully dealt with in the literature. N. I. Bezukhov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

659. Ericksen, J. L., Characteristic directions of certain equations of plasticity, *Mathematika* **3,** 56–62, 1956.

Author considers an incompressible, ideally plastic material defined by the stress-deformation relations

$$s_{ij} = F_1 e_{ij} + F_2(e_{ik}e_{kj} - \tfrac{1}{3}\delta_{ij}) \qquad [1]$$

where s_{ij} is the deviatoric stress tensor and

$$e_{ij} = (d_{km}d_{km})^{-\frac{1}{2}} d_{ij}$$

where d_{ij} is the rate of deformation tensor. F's are assumed to be continuously differentiable functions of $\omega = 3 \times 6^{\frac{1}{2}} \det e_{ij}$. To avoid complex variables it is assumed that $-1 \leqq \omega \leqq 1$. Following a previous paper [M. Baker and J. L. Erickson, *J. Washington*

Acad. Sci. **44**, 33–35, 1954], it is further assumed that

$$F_1 > F_2 e_M \text{ if } e_N \neq e_P$$
$$F_1 \geqq F_2 e_M \text{ if } e_N = e_P \quad (M, N, P \text{ distinct}),$$

where e_N are the eigenvalues of e_{ij}. Characteristic directions for the system of equations comprising equations of motion, the condition of incompressibility and the stress-deformation relations [1] are then investigated.

It is first shown that if $\omega = 0$ (one eigenvalue of e_{ij} is zero) real characteristic directions exist and these make the angle $\varphi = \pm \pi/4$ with the eigenvectors corresponding to non-zero eigenvalues.

The case of $\omega = \pm 1$ (e_{ij} has equal eigenvalues as in the case of simple extension) is considered next. It is shown that there exist two families of real characteristics if and only if $F_1(\pm 1) \mp 2F_2(\pm 1)/\sqrt{6} = 0$.

Finally, author remarks that it would be of interest to determine necessary and sufficient conditions on the F's for there to exist real characteristic directions for all ω in the interval $-1 \leqq \omega \leqq 1$.

E. T. Onat, USA

Courtesy of Mathematical Reviews

660. Talatonov, Yu. N., Determination of the moment of torque arising on a drum while wire is being wound on it (in Russian), *Sb. stud. rabot. Mosk. tekhnol. in-ta myas. i moloch. prom-sti* no. 4, 64–69, 1956; *Ref. Zh. Mekh.* no. 4, 1957, Rev. 4743.

The problem is investigated of the combined elastic-plastic deflection and tension of a wire when it is being wound on a drum. It is assumed that the force tensioning the wire is known and that the mechanical properties of the material are characterized by extension-compression curves with linear strengthening. The paper contains errors and misprints; in the deformation formulas the modulus of elasticity is omitted. The final formula is wrong.

S. V. Boyarshinov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

661. Glikman, L. A., and Babaev, A. N., A rational application of Sachs' method in determining the residual stresses in compact and in hollow cylinders (in Russian), *Zavod. Lab.* **22**, 4, 466–472, 1956; *Ref. Zh. Mekh.* no. 4, 1957, Rev. 4710.

A modified Sachs method is proposed for the determination of residual stresses in cylinders and disks. The determination of the complete diagrammatic drawing is carried out on one sample by the progressive removal of layers, first by boring and then by turning. Stresses in the inner zone are found by means of interpolation.

The original residual stresses in the outer part of the cylinder or disk are equal to the sum of stresses which were taken off in the outer layers in the preliminary borings and the stresses left over after the boring and determined during turning.

An experimental determination was carried out on disks made from carbon steel, by Sachs' method and by the modified method. In the latter case the results of the diagram drawn of the stresses appear to be the more reliable. It was shown that wire strain gages, while much simpler, guarantee no less precision in the measurement of deformation than the optimeter.

N. M. Rudnitskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Rods, Beams and Strings

(See also Revs. 650, 653, 656, 691, 692, 694, 695, 709, 745, 769, 800, 812, 857)

662. Smith, T. F. W., Graphical method for oblique bending, *Engineer, Lond.* **206**, 5348, 129–130, July 1958.

Graphical constructions, using the Mohr area-moment circle, are described for locating the neutral axis and for drawing the stress distribution diagram for a beam section subject to oblique bending.

From author's summary by R. T. Severn, England

663. Ranov, T., and Wolko, H. S., The location of maximum principal stresses, *Proc. Amer. Soc. civ. Engrs.* **84,** ST 3 (*J. Struct. Div.*), Pap. 1269, 31 pp., May 1958.

While in a great number of practical beam applications the location of the numerically largest principal stresses and maximum shearing stresses presents no special problem, i.e. they occur in the critical sections at the outermost fibers and neutral axis respectively, it is well known that cases exist in which these stress extrema are induced at intermediate fibers. It appears, however, from a reasonably thorough search of the literature, that this question has not been exhaustively treated and, so far, no general method or design criterion has been offered to provide a rapid check on the possible occurrence of the stress extrema at such intermediate locations. This paper summarizes such a method and presents it in the form of design charts for two common cross-sectional shapes. In these two cases it should be possible to ascertain with relative ease whether or not a given beam must be designed on the basis of these "shifted" maximum stresses or not. The treatment shows further that only computation of a few comparatively simple characteristic parameters is required for a solution of a given problem. From authors' summary

664. Crawford, L., Pipe stress analysis for static and dynamic loading, Soc. Nav. Arch. Mar. Engr. Pap. 3, 41 pp., Nov. 1957.

The paper is an extension with graphic illustration of the matrix approach of pipe-stress analysis suggested by Brock for solving complicated engineering problems often encountered by design engineers. The method treated seems to be very useful for machine computation. To make the paper self-contained a section on elementary matrices has been added to the text.

A. M. Sengupta, India

665. Chamberlin, S. J., Spacing of spliced bars in beams, *J. Amer. Concr. Inst.* **29**, 8, 689–697, Feb. 1958.

Beams, 6 × 6 in. in cross section with a 32-in. span, contained a single, spliced #4 bar, or two #4 bars, spliced in the region of constant moment. Lengths of lap were 3, 6, and 12 in. and clear spacings between the lapped bars were 0, ½ and 1 in.

Lapped lengths of 12 in. developed yield point stress in both the single and double bars. Single-bar beams failed by splitting of the bottom cover. Side splitting occurred in all of the double-bar beams. High bond stresses were developed. Load-deflection curves and ultimate loads showed little difference in strength between adjacent and spaced splices.

From author's summary

666. Crossland, B., and Bones, J. A., Behaviour of thick-walled steel cylinders subjected to internal pressure, Instn. Mech. Engrs., Prepr., 20 pp., 1958.

In this paper the literature on the strength of thick-walled cylinders subjected to internal pressure is reviewed and equations are given which enable the initial yield pressure, collapse pressure, and ultimate pressure to be calculated from shear stress-strain data. Pressure tests on thick-walled cylinders made from 0.15% carbon steel, 0.3% carbon steel, and Vibrac steel are described, the maximum pressure reached being 42 ton/in². For 0.15% carbon steel, results of tests on cylinders with a ratio of outer to bore diameter of up to 805 are given. Numerous tensile and torsion tests have been carried out on these steels and these are fully reported.

For the 0.3% carbon steel which was tested first, no measurements were made of initial yield and collapse pressures. The results for the 0.15% carbon steel, however, show good agreement with the calculated values if allowance is made for the influence of shear stress gradient when computing the initial yield pressure. With Vibrac steel the experimental results lie between the two curves computed from the extreme shear stress–strain curves. The experimental pressure–expansion curves at large strains and the ultimate pressures for the three materials all agree very well with the computed values. Values of the ultimate pressures have also been calculated from several empirical equations but they all give considerable errors, though up to a diameter ratio of 4 the mean diameter formula is satisfactory.

From authors' summary

667. Hendry, A. W., New method for the analysis of beams on elastic foundations, I and II, *Civ. Engng., London* **53,** 621, 297–299, Mar. 1958; **53,** 622, 444–446, Apr. 1958.

The deflection curve of the beam is expanded in terms of normal functions, defined by the corresponding lateral vibration problem, which are known to consist of linear combinations of trigonometric and hyperbolic functions. The mutual orthogonality of these normal functions leads to great simplification in the strain energy integrals for the beam, which makes the use of such expansions economical. If both ends of the beam are hinged, the method reduces to a single sine series, which is the most frequently employed version of this approach. Author considers free-free beams and shows in several numerical examples that this procedure results in rapid convergence under a wide variety of loading conditions.

M. Hetenyi, USA

668. Angeleiko, V. I., Influence of transverse horizontal forces on rail stresses (in Russian), *Trudi Khar'kovsk. inzh. zh.-d. transp.* no. 26, 112–142, 1956; *Ref. Zh. Mekh.* no. 4, 1957, Rev. 4984.

The basis taken for the calculation is the principle of separate investigation of the deformation by deflection in the horizontal plane and the torsion. The problem is brought to the solution of the differential equation for torsion

$$M_k = -C\frac{d\varphi}{dx} + Db^2\frac{d^3\varphi}{dx^3}$$

where φ is the angle of torsion, C the torsional rigidity, D the bending rigidity, b the distance between the centers of gravity, from the head to the sole of the rail. The rail is examined as a multiple-span I beam bonded in the central span with a concentrated load. Assuming that the value of M_k between two adjoining supports is a constant, author obtains an expression for the angle of torsion of the beam with any number of spans. Solutions are given for single-, three-, and five-span beams.

E. A. Raevskaya

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

669. Kosimodamianskii, A. S., Bending of anisotropic beams under the action of a homogeneous load (in Russian), *Uch. zap. Rostovck n/D in-ta* **32,** 4, 75–94, 1955; *Ref. Zh. Mekh.* no. 4, 1957, Rev. 4590.

The elastic equilibrium of a beam of constant section deformed by surface and volume forces is studied; it is assumed that the ends of the beam are fixed arbitrarily, that the stresses acting are equivalent to a bending load uniformly distributed along the length of the beam, and that the material of the beam is homogeneous and isotropic and in each point has a plane of elastic symmetry normal to the axis of the beam. Examination of the problem of bending is reduced to determining for the beam section two stress functions φ and F which satisfy the equations

$$\left[a_{44}\frac{\partial^2}{\partial x\partial y} - 2a_{45}\frac{\partial^2}{\partial x\partial y} + a_{55}\frac{\partial^2}{\partial y^2}\right]\varphi = f$$

$$\left[\beta_{22}\frac{\partial^4}{\partial x^4} - 2\beta_{26}\frac{\partial^4}{\partial x^3\partial y} + (2\beta_{12}+\beta_{66})\frac{\partial^4}{\partial x^2\partial y^2} - 2\beta_{16}\frac{\partial^4}{\partial x\partial y^3} + \beta_{11}\frac{\partial^4}{\partial y^4}\right]F = \psi$$

$$\beta_{ij} = a_{ij} - \frac{a_{i3}a_{j3}}{a_{33}} \quad (i,j = 1,2,3)$$

and the boundary conditions

$$\varphi = \alpha, \quad \frac{\partial F}{\partial x} = \beta, \quad \frac{\partial F}{\partial y} = \gamma$$

where f, ψ, α, β and γ are known expressions containing arbitrary constants. These constants are determined from the conditions of fixing of the beam. A detailed examination was made of the bending of an anisotropic beam of elliptical cross section under the action of a load uniformly distributed along the length of the beam arbitrarily fixed at the ends and, in the same conditions of bending, of an orthotropic beam of rectangular cross section.

A. K. Rukhadze

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

670. Szelagowski, F., A rotating disc with a rigid circular inclusion at the center (in English), *Arch. Mech. stos.* **10,** 2, 155–161, 1958.

The distribution of displacements and stresses in a rotating elastic disk with rigid concentric inclusion is obtained on the basis of the properties of elementary analytic functions. The solution of the problem is obtained by superposing two states of stress: the state in a homogeneous disk due to mass forces and a state of stress chosen in such a manner that the displacement at the boundary of the rigid inclusion is equal to zero.

J. Golecki, Poland

671. Mikeladze, M. Sh., Designing rotating anisotropic disks with nonsymmetric cross section (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 11, 103–106, Nov. 1956.

The state of stress in an axially symmetrical, cylindrically orthotropic disk with slightly curved middle surface has been discussed. The solution consists of two second-order differential equations for radial forces T and slopes φ. Each equation involves derivatives of one of the magnitudes T and φ only. A very simple form of the solution (one fourth-order differential equation) for the case of thin rotating shell with constant thickness has been obtained.

M. Sokolowski, Poland

672. Hirschberg, M. H., and Mendelson, A., Analysis of stresses and deflections in a disk subjected to gyroscopic forces, *NACA TN* 4218, 20 pp. + 7 figs., Mar. 1958.

Disks in rotation are usually studied as plane elasticity problems. But when plane of rotation is itself rotated, forces normal to this plane are developed which deflect disk, induce vibratory bending and increase stresses in shaft. Such gyroscopic loads occur in jet-engine disks or in high-speed disks used in missiles, whenever airplane or missile changes direction.

Differential equation of deflection of such disks is derived in present paper for variable thickness disks. For constant thickness disks, solutions are obtained by a finite-difference method,

and results are presented in dimensionless form. Variable thickness disks subjected to temperature gradient are also studied, and a method of solution is presented.

H. Fernandez Long, Argentina

673. Obodovskii, B. A., The case of a rotating disk, weakened by a needlelike opening (in Russian), *Sb. Nauch. Tr. Zhdanovsk. Metallurg. in-ta* no. 3, 300–310, 1955; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5867.

By needle-like opening is understood an opening whose radius R_2 is very small in comparison with the disk's radius R_1 (for instance, $R_2 = 10^{-2} R_1$ or $R_2 = 10^{-3} R_1$). An investigation is made of the ultimate transition of the solution of the problem of the rotating disk with an eccentric round opening obtained earlier by the author, following the method evolved by N. I. Muskhelishvili [*Sb. Nauch. tr. Zhdanovsk. Metallurg. In-ta*, 1955, (3), 293–299], to the solution of the problem of the rotating disk with a needle-like opening. Formulas are built up, in elementary functions, for the stresses in the vicinity of and on the contour of the needle-like opening.

A. D. Kovalenko

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Plates, Shells and Membranes

(See also Revs. 643, 666, 696, 697, 698, 699, 700, 701, 711, 754, 789, 792, 802)

Book—674. Pucher, A., Influence surfaces for elastic plates [Einflussfelder elastischer Platten], 2nd edition, Vienna, Springer-Verlag, 1958, viii + 15 pp. + 80 tables. $8.35.

Author presents 81 influence surfaces for bending moment components in elastic plates at salient points and directions. The information is given in form of large-scale topographic contour maps. The material includes 61 maps for rectangular plates of side ratios 0.8, 1.0 and 1.2, under a variety of edge conditions; 13 maps for infinite and semi-infinite strips, and 7 maps for circular plates. In a comprehensive introduction an outline is given of the theory of influence surfaces, and of their evaluation and extension to cases not directly covered in the text.

A most useful reference work for designers and researchers in structural mechanics.

M. Hetenyi, USA

675. Conway, H. D., The flexure of infinite rectangular plates of varying thickness (in English), *Ing.-Arch.* **26,** 143–145, Mar. 1958.

The title problem is considered for a clamped edge of the long side and which is parallel to a free edge bent by any system of loads. A solution is obtained for an exponential variation of flexural rigidity perpendicular to the long edge, and for periodic loads along the free edge.

H. G. Lew, USA

676. Hicks, R., Laterally loaded plates. Moment distribution around a small circular hole, *Engineer, Lond.* **205,** 5328, 350–355, Mar. 1958.

Author finds an expression for the maximum bending moment around a small circular hole in a bent plate and compares this with the moment which would occur without the hole. Classical plate theory is used in the analysis, which starts with a known solution for the unperforated plate and is then corrected for the effect of the hole by adding suitable terms that free the boundary of the hole.

R. E. Beckett, USA

677. Rumpel, G., Behavior of thin plates in corners (in German), *Bauingenieur* **33,** 3, 50–54, Feb. 1958.

A triangular corner element is studied. Sides of corner are both hinged, one hinged and the other free, one clamped and the other hinged, one clamped and the other free, or both clamped, respectively. It is shown that, for corner angles differing from $\pi/2$, the torsional moments, and consequently also the usually used equivalent corner force, equals zero as do the bending moments. Under some specified circumstances this applies also to corner angle equalling $\pi/2$. In fact, torsional moments are possible for corner angle of $\pi/2$ only when both sides of corner are hinged, or one hinged and the other free.

Corner displacement of a triangular plate is prevented not by a corner force but by distributed reactions approaching, in some cases, a single reaction force at corner for angle equal $\pi/2$.

The conclusions are deduced, first by pure equilibrium considerations, then by pure compatibility considerations. At the end of this very clear paper author shows how the findings can be studied by means of principle stress trajectories.

E. Steneroth, Sweden

678. Yakimov, S. K., Some problems of computation for round and ring-shaped plates, supported at separate points (in Russian), Raschet prostranstvennuth konstruktsii no. 3, Moscow, Gos. izd-vo lit. po str-vu i arkhitekture, 509–559, 1955; *Ref. Zh. Mekh.* no. 2, 1957, Rev. 2203.

The problem is examined of the deflection of a complete plate or of a plate with a central opening with constant thickness, under the action of a distributed axially symmetrical loading and supported at several points, distributed equidistantly from each other on the periphery, concentrically to the contour. The internal and external contours of the plate can be free, freely supported, and tightly closed. This problem converges with the problem on the axially symmetrical bending of the plate (by) forces distributed on the surface and periphery, and with the "basic" problem on the bending of a plate by a reciprocal system of forces in equilibrium, with a load distributed evenly over the periphery and concentrated forces distributed on the same periphery. As the initial solution the solution of the "basic" problem for a complete infinite plate is selected. By means of superposition on this solution of the solution of plates, loaded with contour forces and with moments possessing cyclic symmetry and selected in conformity with the boundary conditions being investigated, determinations are made, in different conditions of support, for the solution of an infinite plate with an opening, of a complete round plate and of a round plate with an opening. Expressions for the moments and forces in an infinite plate with an opening and in the complete round plate, in which the contour appears free or rigidly fastened, are found with the aid of Euler's formulas in their finite form, while for the remaining cases, in rapidly converging series. In the case of the "basic" problem, curves are given of the moments and forces for the periphery and radii of the entire infinite plate, supported at six points, and for the entire round plate, loaded only with contour forces and moments, and the corresponding plate, supported at six points. A method for forces is put forward for determining the superfluous unknown reactions at the points of support. A method is shown to calculate deflection due to concentrated forces in sectorial plates and plates in the form of round rectangles, freely supported on the radial sides. Some ideas are advanced on approximate ways of computing the "basic" problem for round plates, using formulas in finite form for infinite and entire round plates.

A. D. Kovalenko

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

679. Anonymous, Deflection of a closed hinged plate of rectangular shape under the action of temperature (in Russian), *Trudi Gruz. politekhn. in-ta* no. 4, 99–102, 1955; *Ref. Zh. Mekh.* no. 2, 1957, Rev. 2199.

680. Oravas, G., Analysis of continuous cylindrical shells by the method of successive approximations, *Struct. Engr.* **36,** 8, 253–266, Aug. 1958.

As iteration procedures of analysis are becoming increasingly popular among practising engineers a method of successive approximations is presented for the analysis of reinforced-concrete cylindrical shells of rotational symmetry continuous at their boundaries and of constant thickness.

This problem is of practical importance in the design of tanks, bins and pressure vessels. The method is based on simplifying assumptions associated with reinforced concrete and therefore subject to definite limitations in its applications. A set of design graphs are included to aid in the numerical work of the designer. Finally, two simple applications of the presented method are given. From author's summary

681. Fialkow, M. N., Limit analysis of simply supported circular shell roofs, *Proc. Amer. Soc. Civ. Engrs.* **84,** EM3 (*J. Engng. Mech. Div.*), Pap. 1706, 40 pp., July 1958.

Paper presents solutions and numerical results of the limit analysis of circular cylindrical shells. Investigation is only for uniform radial loading and boundary conditions of free longitudinal edges, with transverse edges simply supported. To simplify calculations, a linear approximation to the Mises and Tresca conditions is used as yield criterion. Assuming long shells (and without edge beams), author infers a statically admissible stress field from the elastic "beam theory" pattern as a lower bound. Two other patterns are assumed as stress fields which extend the applicability of analysis to shorter shells. The three displacement patterns for the kinematically admissible velocity fields, serving as upper bounds, are again similar to those associated with the collapse of simple beams. Results for wide range of shape parameters, tabulated and plotted in curves, show that deviations between the mean of bounds and either bound for the collapse pressure parameter vary between 2 and 25%.

Extension of solutions to cover other types of loading, especially that of uniform dead load and with edge beams, will make the analysis more applicable to practical cases of structural cylindrical shells. Z. Karni, Israel

682. Gmur, O., Computation of double curved shells and experiments carried out on such shells, composed of hollow bricks (in German), *Schweiz. Bauztg.* **76,** 22, 329–336, May 1958.

Method of A. Pucher [see *Bauingenieur* 1937] for calculation of membrane forces in shells curved in two directions is applied to a special type of translation shell which is originated by a generatrix in a vertical plane sliding along a fixed directrix. By introducing Airy's stress functions (F) author obtains a partial differential equation for F which is transformed by finite difference approximation in a system of linear equations. Special attention is given to the distribution of the tangential stresses on the edges by an additional computation, since solution of finite difference approximation does not permit computing it directly. The numerical example is calculated for a shell, circularly shaped in both directions, supposing two different net divisions. Comparison shows that a sufficient approximation is obtained by a net with only 16 squares which requires the solution of 9 equations.

Tests made with a shell consisting of hollow clay tiles (special type of bricks) show good agreement in the central part between measured stress distribution and that calculated by membrane theory. Edge-disturbances caused by the edge-beams damp rapidly towards the center of the shell surface

The very favorable stress distribution in this type of translation shell enables carrying out economically wide-spanned shell-roofs with hollow clay tiles, adding only a small layer of concrete on the upper side. Calculation by membrane theory is sufficient for dimensioning the structure. H. Beer, Austria

683. Mainzer, J.-F., Determination of stress distribution, with the help of membrane theory, in the skin of a spherical container under tangential load generated through equidistant supports situated along an arbitrary horizontal circle, *Ing.-Arch.* **26,** 81–92, Mar. 1958.

Closed spherical gas-holders and fluid-receivers are often supported along a single horizontal circle. Paper deals with the calculation of stresses of such containers with the help of the known membrane theory of shells of revolution.

As an introduction, author discusses the elementary case of symmetrical loading and deduces simple formulas for stresses resulting from dead weight, fluid pressure, interior superpressure and snow load. The case of a cyclically distributed tangential load acting along the supporting ring is then dealt with. Author seeks to replace the supporting ring by supports distributed in equal distances along the same ring. First of all, line-like supports are supposed, and the stresses arising in that case are determined. It is shown that, approaching the ends of the supporting places, the meridional stresses remain within limited values; the shear-stresses, on the contrary, increase infinitely. But the situation is quite different if the line-like supports are replaced by supporting plates having extension also in the meridional direction. In this case, all the stresses remain limited, and if an adequate number of supports is applied, the surplus stresses generated through the local support diminish rapidly parallel with the distance from the supporting places. Author does not compare the stresses resulting from the deduced theory to the stresses computable on the basis of the theory of bending. He will show this comparison in connection with a numerical example in a later paper. P. Csonka, Hungary

684. Oravas, G.-A., Stress and strain in thin shallow spherical calotte shells (in English), *Publ. Int. Assn. Bridge Struct. Engng.* **17,** 139–160, 1957.

Author obtains formal solution for stresses and strains in segmental, spherical shells. The effect of the transverse bending stiffness of the shell is taken into account; it is believed that the class of problems considered has not been treated elsewhere with this generality. Method of collocation is used to obtain the approximate satisfaction of boundary conditions in specific cases; the shell is assumed to have a regular polygonal horizontal projection.

The solutions are quite complicated mathematically, and numerical results, although alluded to, are not shown. A quantitative evaluation of the effects of the inclusion of transverse bending is not made. M. E. Raville, USA

685. Akhvlediani, N. V., and Shaishmelashvili, V. N., Evaluation of shells of double curvature according to their degree of failure (in Russian), *Tr. in-ta stroit-dela Akad. Nauk GruzSSR* **5,** 61–71, 1955; *Ref. Zh. Mekh.* no. 4, 1957, Rev. 4711.

An investigation is made of the carrying capacity of shells of double curvature, rectangular in plane when under the action of vertical symmetrical load. The scheme of formation of plastic hinges is accepted on the basis of the experimental data brought into the work. The solution is obtained with the aid of the kinematic method of calculating the carrying capacity, based on the

constitution of the equation for the work of the external and internal forces on the transpositions made when the system is converted into a kinematic chain. A mistake by N. V. Frolov ["Experimental investigation of a closed-collapsed brick-kiln. Materials and construction in accordance with modern architecture." *Izd-vo Akad. Arkh. SSSR* **2,** 1948] is pointed out during construction of the equation for the work.

D. D. Ivlev
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

686. Kempner, J., Energy expressions and differential equations, *J. Ship. Res.* **2,** 1, 8–19, June 1958.

Energy expressions and the related equilibrium equations and natural boundary conditions for the determination of the stresses in and displacements of uniform, thin-walled cylinders of arbitrary cross section loaded in an arbitrary manner by surface and edge forces and moments are presented. The derivations are based upon the Kirchhoff-Loue assumptions of the classical theory of shells and are performed to within a degree of accuracy by Flugge in his derivation of the equilibrium equations applicable to circular cylindrical shells; hence, in terms of stress resultants, the exact, small deflection equilibrium equations are obtained. Methods of simplification of the relations derived and of solution of the differential equations presented are indicated.

From author's summary by H. F. Faught, USA

687. Andreeva, L. E., Calculation for corrugated membranes (in Russian), Raschety na Prochnost'i Mashinostroenii, Moscow, Mashgiz, 1955, 100–123; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5879.

688. Kalynyak, N. I., Bending of isotropic plates having equal circular holes (in Russian), *Nauch. zap. L'vovsk. politekhn. in-ta* no. 30, 52–64, 1955; *Ref. Zh. Mekh.* no. 4, 1957, Rev. 4585.

Investigation of the stress distribution about two equal circular holes in a plate of thickness h bent by moments and normal stresses applied to its edge. The plate is considered infinite. The solution of the problem is given in bipolar coordinates with the aid of the transformation

$$x + iy = -a \coth \frac{i(\beta + i\alpha)}{2}$$

where x, y are the Cartesian coordinates, a is a real number, and α and β are the bipolar coordinates.

The method of solution is as follows: The bending function of the mean plane of the thin isotropic plate is represented by

$$W(\alpha,\beta) = W_0(\alpha,\beta) + W_1(\alpha,\beta)$$

where $W_0(\alpha,\beta)$ is the known bending function of the whole plate, and W_1 corresponds to the additional stress state occurring in the plate due to the whole. This function is sought in the form

$$\frac{W_1}{l} = \sum_{n=1}^{\infty} [A_n \cosh(n+1)\alpha + \beta_n \cosh(n-1)\alpha] \cos n\beta +$$

$$K(\cosh\alpha - \cos\beta)\ln(\cosh\alpha - \cos\beta)$$

The unknown coefficients A_n, B_n and K are determined from the contour conditions for $\alpha = \pm\alpha_1$

$$M_\alpha = m(s_\beta)$$

$$N_\alpha + \frac{\cosh\alpha - \cos\beta}{a}\frac{\partial H_{\alpha\beta}}{\partial\beta} = p(s_\beta)$$

and the conditions at infinity

$$\sum_{n=1}^{\infty}(A_n + B_n) = 0$$

where M_α, $H_{\alpha\beta}$ and N_α are the bending and torsional moments and the intersecting forces, $m(s_\beta)$ are the bending moments referred to unit length of the contour, and $p(s_\beta)$ are the stresses, normal to the mean plane of the plate, applied to the edge of the hole.

M. A. Savruk
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

689. Borsuk, K., Application of the Koepcke-Papkovitch method to orthotropic plates (in Polish), *Rozpr. Inzyn.* **6,** 1, 95–101, 1958.

Paper is concerned with the generalization of the Koepcke-Papkovitch method to orthotropic plates with particular regard to the determination of the system of eigenfunctions of the homogeneous equation. For various types of orthotropy corresponding transcendental equations are derived, containing as unknowns the roots of the characteristic equations.

M. Bieniek, Poland

690. Pen'kov, O. M., and Bondarchuk, O. S., Investigation of stresses in the members of the impeller of a mineshaft centrifugal fan (in Russian), *Prikl. Mekh.* **1,** 3, 281–294, 1955; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 1233.

Results are given of an experimental investigation of the stresses in a revolving centrifugal fan type VTsO-4, in mine 5–6, named M. I. Kalinin. The fan investigated had a single-sided inlet, an impeller with an outer diameter of 4m, a peripheral velocity of 76.4 mps, a maximum pressure of 475 mm water column, number of working blades—24, and a guiding system of thirteen blades. The measurement of the deformations was carried out at different angular settings of the blades of the guiding system by means of strain gages glued on the disks (rotor and stator) in the form of T-shaped rosettes, and on the blade in the form of triangular rosettes. During the investigations a voltage divider with sliding contact and a four-channel strain gage instrument were used. The experiments established (1) the actual influence of aerodynamic pressure on the stressed state of the disks and blades; the alteration of the angle of the blades of the guiding system at constant rpm resulted in an increase in the values of the radial and surrounding stresses in the disks by 1.2 to 1.5 times, and in a significant redistribution of the principal stresses in the blade; (2) the significant effect on the deflection of the disks, in conjunction with the one-sided distribution of the working blades, of aerodynamic pressure and the conic median surface covering the disk; (3) the presence, apart from static ones, of observable dynamic stresses, conditioned by the unbalance of the revolving rotor mass and the unevenness of the pressure of the air flow on the surface of the rotor.

The results of the experimental investigations are compared with the stresses found by calculation on the assumption that the disks work as plane round plates only for tension due to centrifugal forces of the natural mass, while the blade works in the field of centrifugal forces as a system of cut strips; here a substantial divergence between the experimental and computed data is disclosed. It has to be noted that the analysis indicated does not appear to have exhausted the subject; modern methods in the construction mechanics of machines permit, at a known dynamic pressure, the evaluation by calculation of the amplitude of the deflection stresses in the disks and the execution of computations for the covering of the disk and blade, taking them to be slanting envelopes exposed to the action of centrifugal forces and aerodynamic pressure.

A. D. Kovalenko
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Buckling

691. Zanaboni, O., Equations in terms of trigonometric series for the flexural deformation of beams with various end conditions (in Italian), *G. Gen. Civ.* **96**, 3/4, 179–192, Mar./Apr. 1958.

The subject material is developed in a straightforward manner in this brief paper. In addition to lateral loading, axial forces are also assumed to be acting so that elastic stability is considered. Orthogonality conditions are discussed. Four specific problems are solved as illustrations. W. H. Hoppmann, II, USA

692. Witte, H., The tipping stability of laterally loaded beams having simple-symmetric cross sections (in German), *Stahlbau* **26**, 12, 380–381, Dec. 1957.

Author exhibits formula, containing two parameters, which he claims can be used to obtain load factor for lateral buckling of beam with simple-symmetric cross section, loaded transversely, axially, and with couples. Different choices of parameters correspond to different boundary conditions. No details of proof are shown. H. J. Weiss, USA

Book—693. Pinadzhyan, V. V., Some questions of the limiting state of compressed components in steel structures (in Russian), Erevan, Izd-vo Akad. Nauk ArmSSR, 1956, 202 pp., 7r.40k; *Ref. Zh. Mekh.* no. 4, 1957, Rev. 4745.

The book presents a systematic investigation of the limiting state of compressed-bent rods. There are five chapters. In the first chapter the evaluation is examined of the limiting state of eccentrically compressed rods of arbitrary section with one axis of symmetry, it being assumed in this case that the material possesses toughness. The customary assumptions are adopted (the hypothesis of plane sections, the disregarding of deformations due to shear and the influence of the pressure of the fibers against each other). The unloading in the transverse section is not taken into account; as always, use is made of the linearized equation of the elastic line of the rod. The edges of the rods are taken to be hinge-supported.

With the given obstacles, expressions are built up for the deflections to cover the cases where plastic deformations occur in the compressed or tensed zone, or even in both; the latter are then used for establishing the relation of flexibility to eccentricity, compression forces and the parameters of the hinge-supported single span rod with differently placed plastic zones (such cases may amount to nine); in the result it is possible to calculate the maximum deflection corresponding to the limiting state, determinable by means of the maximum value of the flexibility of the rod at a fixed value of the ratio of the first critical force to the force exercised by the yield of the evenly compressed rod and the relative eccentricity.

The following chapter is given up to the determination of the limiting condition of hinge-supported rods under the simultaneous action of longitudinal and transverse loading in the conditions of linear toughening, transverse section with one axis of symmetry. Cases are examined of concentrated and evenly distributed transverse loads. As previously, expressions are given for deflection in relation to the development of plastic zones on the transverse section (three variants) and along the length of the bar. Here the number of possible conditions, compared to eccentrically compressed rods, is reduced from nine to four.

In chap. 3 is demonstrated the calculation of the limiting condition of compressed-deflected bars composed of ideally plastic material, on the assumption that the bar is bent in the shape of a sinusoid. Deductions are made for the initial correlations for three possible cases of distribution of stresses over the transverse section. From their analysis, author shows that the carrying capacity of a rod in an elastic-plastic condition is determined (for given values of the transverse section, load, and a given curve of relationship between the stress and the deformation) by (1) the maximum ordinate of the curve of the mean stress against the deflection indication or the maximum ordinate of the curve of the flexibility of the rod against the greatest thickness of the plastic layer in the compressed zone; and (2) the equality of the maximum fibrous stress at the limit of stability or by the condition of attainment of the maximum fibrous axial deformation of the limiting value.

There follows a detailed investigation of the cases of an eccentrically compressed rod with an arbitrary box-shaped transverse section of open outline, of the simultaneous action on the rod of longitudinal and transverse forces, and of a compressed rod with initial curvature. Practical recommendations are made for calculating the limiting condition of compressed-deflected rods.

The fourth chapter contains a discussion of the results of experiments by Ros, Grünings, and Kollbrunner, and also of the author's own experiments in the Zakavtaskii institute of building (Tiflis) on the study of the behaviour of compressed-bent steel rods; comparing experimental results with the calculated ones, containing actual data to a greater extent than assumptions, author concludes that the theory is promising.

The last chapter gives a calculation for the carrying capacity of an H-type girder in transverse section when an axial force is arbitrarily applied to the plane of the cross section. The book is based on the author's previously published works.

E. I. Grigolyuk
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

694. dos Santos, S. M. G., Lateral buckling of beams with single connections (in French), *Publ. Int. Assn. Bridge Struct. Engng.* **17**, 197–208, 1957.

The stability of equilibrium (lateral buckling) of a beam is investigated. The beam is simply supported and hindered from turning away at its ends. A point of the middle cross section is hindered from lateral movement. A single loading force acts at the middle cross section. The critical value of this loading force is computed; for this purpose, the so-called statical method is employed. That point of the middle cross section where the loading force acts is not decidedly defined. Reviewer believes that the employable method and the result depend on this definition.

J. Barta, Hungary

695. Shanshiashvile, A. M., Determination of the rigidity modulus of steel columns and beams with a partially fastened contour (in Russian), *Trudf Gruz. politekhn. in-ta* no. 4, 231–238, 1955; *Ref. Zh. Mekh.* no. 2, 1957, Rev. 2343.

A determination is made of the relative angle of torsion of a thin-walled bar of rigid open profile, partially closed with strips and cross stays. In determining the forces of the reciprocal action between the bar and the reinforcement the local deformations of the bar a.e not taken into account. The problem is solved on the basis of the theory of torsion of thin-walled bars. A numerical example is given. V. A. Mar'in
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

696. Bijlaard, P. P., Method of split rigidities and its application to various buckling problems, *NACA TN* 4085, 80 pp. + 3 tables + 23 figs., July 1958.

Comprehensive summary of work done previously by author is presented. [e.g., AMR **6** (1953), Rev. 2460; AMR **7** (1954), Rev. 1069, 1070; AMR **9** (1956), Rev. 431; AMR **10** (1957), Rev. 3979]. Basic principles are reviewed and illustrated on new examples. Correctness of method, which is basically approximate, is demonstrated by comparison with exact calculations or tests.

K. S. Pister, USA

697. La Tegola, A., On the stability of equilibrium of plates (in Italian), *G. Gen. Civ.* **96**, 3/4, 237–244, Mar./Apr. 1958.

Paper concerns the elastic stability of plates of varying thickness. Attention is given to a rectangular plate with the following loading and support conditions. At one pair of edges the plate is free, and there is a linear variation in plate thickness between these edges; the plate is loaded in uniform compression along one of these edges. At the other pair of edges, along which the applied load is reacted, the plate is simply-supported. An approximation to the initial stress distribution is first found, and then an energy method (based on an assumed, and approximate, form for transverse displacements at instability) is used to determine an approximation to the critical load. Specific numerical results for various cases are presented at the end of the paper.

H. G. Hopkins, England

698. Massonnet, C., General theory of buckling of simply supported or built-in rectangular plates, with flexural and torsional resisting stiffeners parallel to the edges (in French), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **5**, 181–193.

Author presents a new theory covering the general field stated in title, based on his tests, carried out in recent years, which have shown that buckling stresses in web plates of solid-web girders are considerably greater than those computed by classical theory of Timoshenko. Following the same energy method as Timoshenko, author uses, in Fourier series developments, the functions representing buckling deflection curves of hinged or built-in ends bars, whose peculiar orthogonality properties simplify the calculations considerably.

Author intends to apply his theory to study buckling of webs stiffened by tubular ribs, as in the Dörnen technique, considering numerical values for torsional to flexural stiffness relation of the ribs within the range of practical cases. This program is proceeding now.

F. Correia de Araujo, Portugal

699. Ishlinsky, A. Yu., A particular transition at the limit in the theory of stability of elastic, rectangular plates (in Russian), *Dokladl Akad. Nauk SSSR (N. S.)* no. 3, 477–479, 1954; *Ref. Zh. Mekh.* no. 3, 1957, Rev. 3419.

The stability of an extremely long plate is analyzed; two opposite edges are supported, and the two other sides are free, when the plate is uniformly compressed along the hinged edges. It is demonstrated that for this plate the limiting value of the critical stress is less than the critical stress corresponding to the cylindrical form of loss of stability.

The author further comes to the conclusion that the Saint-Venant principle is in some degree inapplicable to bodies of the type of a flat plate extended in any one direction.

B. L. Abramyan

Courtesy of Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

700. Weinitschke, H. J., On the buckling problem of shallow spherical shells under external pressure, *J. Aero. Sci.* **25**, 2, 134–135 (*Readers' Forum*), Feb. 1958.

Apparent scattering in test data have been interpreted in two different ways. Klein [AMR **11** (1958), Rev. 442] attributes this to initial irregularities of specimen, and Reiss, supported by a theoretical investigation by Reiss, Greenberg and Keller [AMR **11** (1958), Rev. 454] on the basis of sudden changes in shape of normal deflection, yielding a periodical behavior of critical load curve as function of a certain geometrical parameter.

Author has solved the equations of axisymmetrical modes by a power expansion series on the Whirlwind-I computer and reports a result widely differing from that obtained by Reiss, Greenberg and Keller.

F. I. Niordson, Sweden

701. Finkel'shtein, R. M., Stability of thin-walled cylinder (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 7, 37–42, July 1956.

The critical value of the hydrostatic pressure causing buckling is obtained as a correction to the "upper" value calculated by von Mises.

J. Solvey, Australia

702. Ryayamet, R. R., Critical load of a conical envelope under the action of uniformly distributed external pressure (in Russian), *Trudl Tallinsk. politekhn. in-ta* (*A*) no. 65, 76–85, 1955; *Ref. Zh. Mekh.* no. 4, 1957, Rev. 4620.

The stability of a full conical envelope of circular section constrained over the lower contour is examined in a linear arrangement.

Equations of the local loss of stability suggested by Kh. M. Mushtari [*Prikl. Mat. Mekh.* **2**, no. 2, 1939] are used for determining the critical load. Neglecting the square of the longitudinal wave compared with the square of the frequency of the surrounding waves, author reduces the system of equations of the 8th degree to an ordinary equation of the 4th degree with variable coefficients. The critical load is determined from the corresponding variation equation. A convenient formula for practical use is given.

A. V. Sachenkov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

703. Poverus, L. Yu., Stability of an envelope of rotation having slight position curvature under the action of a uniformly distributed external pressure (in Russian), *Trudl Tallinsk. politekhn. in-ta* (*A*) no. 65, 124–133, 1955; *Ref. Zh. Mekh.* no. 4, 1957, Rev. 4618.

Examination of the stability, under the action of external pressure, of an axially symmetrical envelope differing from a cylinder. Author starts from equations of the local loss of stability of inclined envelopes and then simplifies them, introducing estimated values found by N. A. Alumyae for a cylindrical envelope.

An example of the determination of the critical pressure for a vat-like vessel is examined; the attachment on the contours corresponds to conditions of free rest.

V. I. Feodos'ev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

704. Egupov, V. K., Three-dimensional stability of compound stringer-type structures for deckings and of frame-type skeletons (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 7, 43–52, July 1956.

Author applies the well-known principle of subdividing a compound structure into elementary components and replacing connections between these components by either springs or loads. The first lead to stability problems; the second, to vibration problems. The resulting boundary-value problem is solved by satisfying compatibility conditions at the common joints of the components.

Two examples show, in very general terms, the application of the method: one, the hull of a ship; the other, the skeleton of a one-story, multibay structure.

J. Solvey, Australia

Vibrations of Solids

(See also Revs. 614, 615, 616, 706, 767, 1043, 1108)

Book—705. Van Santen, G. W., Introduction to a study of mechanical vibration, 2nd edition, New York, Macmillan Co., 1958, 310 pp. $6.50.

Author states that the purpose of the book is "to review the elementary theory of mechanical vibration, as well as some of the more important problems of vibration encountered in practice."

This he has done rather well. In addition to the usual material, interesting topics discussed are: electrical analogies, vibration isolation, practical application of experimental resonance curves, wave propagation, sound, balancing methods, damping processes, special vibration phenomena such as flutter, physiological and mechanical detrimental effects of vibration, principles of measurements of vibration, vibration instruments, and practical hints on vibration measurement. The instruments discussed are mostly of the author's company.

Occasional obscurities and oversimplifications are in evidence, as may be expected for so wide a coverage in so few pages. For example, in discussing critical whirling speeds of shaft disk systems no reference is made to gyroscopic effects or higher modes of vibration. The reader must exercise care in judging the applicability of the formulas given to his own problems. The text is marred by a number of careless typographical and minor errors. Reviewer's copy had first 16 pages of text missing. The book is well organized and written in readable style. It should be particularly useful to the practicing engineer, as well as interesting to those desiring a survey of applications of vibration theory.

N. H. Jasper, USA

Book—706. Pattantyus, G. A., Vibrations in mechanics [Gepeszeti Lengestan Lengesi Folyamatok A Muszaki Gyakorlatban], Budapest, Akademiai Kiado, 1952, 264 pp.

Book represents an unusual arrangement of subject material treated. Emphasis is placed on practical problems and rapid solutions, although tie-in with classical vibration theory is made whenever possible. In a broader interpretation of vibrations, periodic motions other than the conventional spring-mass system are examined, provided that they can either act as the forcing function or contribute to the vibration. Such cases include free and fixed piston engines, rotary machines, sieves, vibrators, reciprocating tools, and the oscillatory motion of fluid columns.

The subject material is divided into six chapters: I. Periodic motions of masses. Forcing functions; II. Free vibration of systems; III. Transmission of vibrations; IV. Damping and damping devices: V. Forced vibration of systems; VI. Harmonic analysis.

The book excels in its presentation of numerous practical applications, accompanied by extensive sample calculations. Theory is brought to bear only to the degree sufficient to solve the problem at hand. Chapters IV and V are especially valuable in their broad treatment of the material and the presentation of many unusual solutions.

Book should be of considerable value to the practicing engineer. However, references to the Western literature on this subject, other than the German, are conspicuous by their absence.

N. A. Weil, USA

707. Lakshmi Kantham, C., Bending and vibration of elastically restrained beams, *J. Aero. Soc. India* **10,** 1, 1–5, Feb.–Mar. 1958.

The influence of end fixity on the deflection under a load and on the natural frequencies of free vibration is studied and the results are presented in the form of graphs and tables.

G. Herrmann, USA

708. Vasil'eva, R., Sheinman, E. M., and Tsekhanskii, K. R., Calculations of the parameters of the elastic component of a wide range vibrating test rod (in Russian), *Tsentr. N.-I. In-ta Tekhnol. i Mashinostr.* no. 68, 11–22, 1954; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 6243.

709. Dimitrov, N., The section forces in beams with oscillating lateral load considering an additional normal force (in German), *Stahlbau* **26,** 4, 107–111, Apr. 1957.

Influence lines and approximation formulas for the well-known title problem with constant axial force are presented.

H. Parkus, Austria

710. Yamamoto, T., On the vibrations of a rotating shaft, *Mem. Fac. Engng., Univ. Nagoya* **9,** 1, 19–115, May 1957.

Comprehensive experimental and theoretical treatise on title subject. Whirling motions of single disk straddling single-row radial ball bearings are principally discussed. Gyroscopic effects are included. Single-row radial ball bearings introduce nonlinearities into system which induce critical speeds of subharmonic oscillation and "summed and differential harmonic oscillations." The latter term is defined by $|p_i \pm p_j|$ where p_i and p_j are natural frequencies of the system, and the numerical value of the sum or difference is always equal to the frequency of shaft rotation. Author presents experimental data to illustrate these motions and then proceeds to explain analytically the possibility of their occurrence. Paper concludes with an analytical investigation of stability criteria for forced vibration in nonlinear systems.

Reviewer believes paper to be a most important contribution to the title subject.

M. C. Steele, USA

711. Berry, J. G., and Reissner, E., The effect of an internal compressible fluid column on the breathing vibrations of a thin pressurized cylindrical shell, *J. Aero. Sci.* **25,** 5, 288–294, May 1958.

Authors study the free oscillations of a thin pressurized cylindrical shell containing compressible fluid. Shallow-shell theory is used to derive a simple formula for the natural frequencies of the coupled fluid-cylinder system. Inertia and compressibility effects of the fluid lower the frequency of wall vibrations of the cylinder. Additional higher frequencies result, however, each associated with a particular number of nodal circles in the oscillating fluid. An approximate frequency formula for heavy liquids is obtained.

A. P. Boresi, USA

712. Grigolyuk, E. I., Small vibrations of thin elastic conical shells (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 6, 35–44, June 1956.

Author gives an approximate solution of nonsymmetrical free vibrations of idealized loudspeaker membrane of conical shape. Using usual energy method and including the effect of the extension of middle plane, formulas for the lowest natural frequency are derived. In the case of near cylindrical membrane, the solution may be simplified with the aid of equivalent cylindrical membrane.

Paper is completed by practical table enabling easy determination of the lowest frequency for various geometrical parameters of the membrane.

K. Julis, Czechoslovakia

713. Sykes, A. O., The evaluation of mounts isolating nonrigid machines from nonrigid foundations, *David Taylor Mod. Basin Rep.* 1094, 47 pp., Oct. 1957.

Mechanical impedance methods are used to calculate isolator effectiveness or attenuation in terms of machine, mount and foundation characteristics. Thirty-four graphs are given of effectiveness versus frequency for various combinations of mount stiffness and damping and machine and foundation mass, stiffness and damping. Only one point collinear attachment is considered.

R. Plunkett, USA

714. Branovskii, M. A., and Kislyi, V. I., Improvement of the vibrational conditions of turbo-assemblies (in Russian), *Elektr. stantsii* no. 3, 25–31, 1956; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 107.

715. Bolotin, V. V., The deflection oscillations of rollers, sections of which have dissimilar principal flexibility (in Russian), *Inzhenernyi sbornik* **19,** 37–54, 1954; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 978.

716. Gorkii, G. Yu., Determination of the periods of natural oscillations of plant of the tower type, taking into account the

elasticity of the foundation (in Russian), *Trudī in-ta sooruzhenii Akad. Nauk USSR* no. 6, 32–40, 1955; *Ref. Zh. Mekh.* no. 4, 1957.

Taking as an example of an arrangement for calculation a vertical ponderable rod with an elastically clamped lower end, and assuming that the horizontal displacement can be neglected, author reduces the problem to calculation of natural frequencies of the transverse oscillation of a ponderable rod.

The use of the method of initial parameter and the energy method was examined and some approximate formulas were obtained for the basic frequency. N. A. Rostovtsev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

717. Klotter, K., New methods and results in the field of nonlinear vibrations (in German), *ZVDI* **100**, 2, 47–48, Jan. 1958.

Wave Motion and Impact in Solids

(See also Revs. 652, 1044)

718. Drummond, W. E., Explosive-induced shock waves. I. Plane shock waves, *J. Appl. Phys.* **28**, 12, 1437–1441, Dec. 1957.

The explosive production of plane shock waves in solids is analyzed in the approximation that third and higher-order terms in the shock strength can be neglected, and a procedure is developed for calculating the attenuation of the shocks. Application is made to the problem of determining the equation of state of the burned explosive gas.

From author's summary by J. Nielsen, USA

719. Drummond, W. E., Explosive-induced shock waves. II. Oblique shock waves, *J. Appl. Phys.* **29**, 2, 167–170, Feb. 1958.

Author solves the title problem for the supersonic case by the method of characteristics. The solutions apply not only to gases but also to metals where the shock pressures are the order of 100,000 atmospheres or greater. Under these conditions, the metal may be treated as a compressible fluid and the flow is analyzed as a wave interaction at a contact surface.

Numerical results are presented for the shock trajectory in aluminum. The results agree with experimental observations provided the equation of state for the explosive which induces the shock is properly chosen. Thus, the technique may be used to estimate the isentropic equation of state of burned explosive gases from experimental measurements. Several equations of state are presented for composition B explosive. [For Part I, see preceding review.] C. C. Taylor, USA

720. Crandall, S. H., Negative group velocities in continuous structures, *J. Appl. Mech.* **24**, 4, 622–623, Dec. 1957.

Wave propagation in which the energy transport is in the opposite direction to the phase velocity seems unusual to one used to dealing with nondispersive and normally dispersive media. Such a phenomenon actually occurs for certain modes of propagation in some periodic structures. For example, the optical mode in Born's NaCl model has negative group velocity. A recent invention, the backward wave tube, capitalizes on the negative group velocity of periodic band-pass-filter circuits.

In a study of the Timoshenko beam on an elastic foundation it was accidentally discovered that over a limited range of wave lengths the fundamental mode has negative group velocity. Since negative group velocities apparently have not been noticed in continuous media before, a more general treatment of the question is given in this note. It is found that negative group velocities do in fact occur in many media. An example is given of a medium whose group velocity is negative for all wave lengths.

From author's summary

721. Brennan, P. J., and Wiseman, H. A. B., The effect of impact on beams and welded structural connections, *Welding J.* **36**, 10, 465s–472s, Oct. 1957.

Initial studies on light beams with welded connections were made under static and dynamic loading conditions. Strains were obtained on the top and bottom flanges near the welded connections. Time-strain curves were recorded for these locations both for impact that did not produce failure and for impact that did produce failure. The time of transmission of the stress wave was obtained between various locations on the beam and the shape of the time-strain curves at these locations compared.

Results show that for the theory used the computed work at failure under impact exceeded the work at failure under static loading for similar beams and welded connections. The ratio of dynamic to static work at failure was from 1.2 to 7.6. A linear relationship exists between the work required for failure in the weld and the area of the failure plane of the weld. A direct relationship also appears to exist between the work required for failure in the weld and the product of the curvature and moment of inertia.

Recommendations for a large-scale test program to produce more positive and conclusive results are made.

From authors' summary

722. Gorkov, P. I., An analysis of the plane-parallel impact of a solid in the presence of friction (in Russian), *Trudī Mosk. in-ta inzh. zh.-d. transp.* **78**, 159–179, 1953; *Ref. Zh. Mekh.* no. 3, 1957, Rev. 2654.

The problem of the plane-parallel impact of an unconstrained solid body on an obstacle is solved for the presence of friction on the assumption that the contours of the sections of the body and the stationary obstacle in a stationary plane containing the path of the center of gravity of the body, at the instant of impact, have a single common point. Two cases are examined: (1) The sliding velocity of the point of reciprocal collision does not become zero during the deformation stage of the impact; (2) this velocity does become zero before termination of the deformation phase. In both cases, the following are determined: the state of motion of the solid at the instant of termination of deformation at the point of mutual collision; the maximum value of the impact momentum; and the change in the velocity field of the points of the solid body during the collision. The corresponding formulas differ substantially from those obtained in the absence of friction. For cases of type 2, the conditions are derived at which slipping of the point of mutual impact is repeated until the end of deformation.

I. B. Pogrebysskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

723. Schillkrut, O. I., The rate of propagation of elastic waves in an incompletely-elastic medium (signal speed) (in Russian), *Dokladī Akad. Nauk SSSR (N. S.)* **106**, 1, 58–60, 1956; *Ref. Zh. Mekh.* no. 3, 1957, Rev. 3514.

The problem is discussed of determining the rate of propagation of an elastic wave in an incompletely-elastic medium, for which the rheological relationship

$$\sigma(t) = b\left[\epsilon(t) - \int_0^t \phi(t-\tau)\,\epsilon(\tau)\,d\tau\right]$$

applies; in which σ = stress, ϵ relative deformation, b dynamic modulus of elasticity, $\phi(t)$ a monotonously decreasing function characterizing the elastic deficiencies of the material. It is maintained that during propagation in an incompletely-elastic medium the perturbation becomes "blurred;" the first to arrive at a given point are the "forerunners" of the fundamental perturbation,—the low harmonics of high frequency, the speed of propagation whereof approaches that of the wave front, equalling, according to the author, $\sqrt{b\rho^{-1}}$ where ρ is the density of the medium.

These forerunners may not be recorded by the registering apparatus. The fundamental part of the perturbation, which is identified by the instrument, consists of oscillations of low frequency, travelling at a velocity less than that of the wave front.

The phenomena described as taking place in an incompletely-elastic medium represent an anomalous dispersion, and are further to be explained by the fact that the higher harmonics fade more quickly than the lower (fundamental) harmonics.

K. I. Ogurtsov

Courtesy of Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

724. Babukov, A. G., On a boundary problem in the deep-well pump theory (in Russian), *Dokladi Akad. Nauk SSSR (N. S.)* **108,** 1, 39–42, May 1956.

Longitudinal motion and stresses of a shaft and tube are governed approximately by a pair of one-dimensional wave equations (with damping term included). The upper end of the rod is moved as $u_1(0,t) = f(t)$, a function of period T, while at the end $x = L$ four different states of stress and displacement prevail during each cycle. Paper concerns only the solution of the boundary-value problem arising. Insufficient information is given for a description of the actual physical problem. R. E. Gaskell, USA

Soil Mechanics: Fundamental

(See Revs. 667, 1083)

Soil Mechanics: Applied

(See Rev. 713)

Processing of Metals and Other Materials

(See also Revs. 654, 660, 762, 948)

725. Brockhaus, J. G., Fischer, F., Graetz, H., and Ohlwein, K., Study on the effect of different working conditions of a three stand cold rolling tandem mill train on the mechanical properties of steel strip (in German), *Stahl u. Eisen* **78,** 14, 955–960, July 1958.

Testing equipment and measuring methods used are described as well as materials tested. Practice of the tests and evaluation of the results is given. Effect of the pass sequence, of the kind of descaling and of the rolling emulsion used on the mechanical properties of the strip rolled is shown.

From authors' summary

726. Buhler, H., Internal stresses in hot rolls having been stressed in service (in German), *Stahl u. Eisen* **77,** 24, 1740–1747, Nov. 1957.

Author describes measuring methods used and gives dimensions of the rolls and the material used for them. Results of measurement on two steel roughing rolls of an old wire rod mill and on two rolls of a heavy plate rolling mill are presented. Results are interpreted with a view to the stress endured and the life of hot rolls. From author's summary

727. Yamanouchi, H., and Hayashi, I., Drawing of sheet through rotation roll, *Castings Res. Lab. Rep., Waseda Univ.* no. 8, 63–66, Nov. 1957.

Authors show theoretical formulation and experimental data of rolling brass by means of high front tension through torqueless rolls. This particular technique, known as Steckel-rolling, has been extensively described in the literature. Authors give no references, which is unfortunate since the Hoffmann and Sachs ["Introduction to theory of plasticity for engineers" McGraw-Hill, 1953, pp. 214–220] modifications for Nadai's solution of von Karman's equation included Steckel rolling as well as effects due to changes in roll diameters.

Experimental results of roll pressures, stresses in bars, and slip are given for 80 to 100-mm diameter rolls with 9.3 to 26.3% area reduction. Results are accompanied by very scant description of apparatus and procedures and lack such basic information as strip velocities, front tensions, friction conditions, and lubricants. J. Frisch, USA

728. Yamanouchi, H., and Matsuura, Y., Measuring the coefficient of friction in cold strip rolling, *Castings Res. Lab. Rep., Waseda Univ.* no. 8, 57–62, Nov. 1957.

Authors measured the coefficient of friction in cold strip rolling using Ford's measuring technique and Hill's theoretical solution. Strip material used was commercially pure aluminum, brass and medium carbon steel with lubricants described only by popular names such as Lanoline, Dynamo oil, etc. Paper is accompanied by tables of experimental results for the three strip materials and six different lubricating conditions. J. Frisch, USA

729. Spiridonov, N. P., and Spiridonov, O. N., Construction of a field of velocities of points in the center of deformation in an ordinary case of rolling with the aid of a coordinated network for a strip worked up on rollers (in Russian), *Trudi in-ta chernoi metallurgii Akad. Nauk USSR* **10,** 90–103, 1956; *Ref. Zh. Mekh.* no. 4, 1957, Rev. 4748.

A description is given of the graphic construction of a field of velocities at the center of deformation during the process of rolling. It is shown how to determine the neutral angle and the zone of adhesion. It is also shown that the field of velocities does not depend on the speed of rolling and the conditions prevailing in the drag of the strip, excluding cases of the influence of velocity on the coefficient of friction. V. G. Osipov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

730. Dinnick, A. A., Determination of the mean specific pressure in plastic deformation during die-stamping (in Russian), *Trudi in-ta chernoy metallurgii Akad. Nauk USSR* **10,** 116–126, 1956; *Ref. Zh. Mekh.* no. 3, 1957, Rev. 3505.

The formulas of S. I. Gubkin ["The theory of working metals by pressure," Metallurgizdat, 1947] and E. P. Unksov ["New ideas in the technology of hot stamping," Mashgiz, 1948] are examined, and the limits of their application defined. A new method is suggested for determining the work of plastic deformation and mean specific pressure in die-pressing. The calculation formulas are derived for pressing without lateral expansion for the axially symmetrical problem in the absence of contact slip. Calculations made by the suggested formulas correspond satisfactorily with experimental data. The scope of these formulas embraces the majority of cases of hot die-pressing using flat dies. It is demonstrated that the occurrence of a region of adhesion on the outline of the contact surface is determined not by the condition $\tau_x \geq 0.5\beta\sigma_u$ in the usual form, but by the condition of equality of the work done in supplementary shear and friction. V. G. Osipov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

731. Baldin, V. A., The resistance of low-carbon steel to plastic deformation (in Russian), "Researches on the strength, plasticity and creep of structural materials," Moscow, 1955, 57–68; *Ref. Zh. Mekh.* no. 3, 1957, Rev. 3721.

An examination in general form of the strength of a low-carbon steel with a ferritic-pearlitic structure. Some data are given on the observed microstructural changes under the influence of in-

cipient plastic deformation, and it is shown that these results agree better with the third theory of constant potential energy in the change of form. P. O. Pashkov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

732. Dahl, W., and Lueg, W., Contribution to the problem of drawing and extruding cold-rolled steel bars (in German), *Stahl u. Eisen* **77**, 25, 1795–1802, Dec. 1957.

733. Nichiporovich, F. V., Study of the elastic behaviour of metals during plastic deformation applicable to the conditions of hot punching (in Russian), Avtorefer. Diss. Kand. Tekhn. N., Belorus. Politekhn. In-ta, Minsk, 1956; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5964.

734. Tomlenov, A. D., Deep drawing of thin-walled pieces with complicated configurations (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 11, 100–102, Nov. 1956.

735. Barton, J. W., Bodsworth, C., and Halling, J., Use of paraffin wax as a model to simulate plastic deformation, Part II—Practical applications of this technique, *J. Iron Steel Inst. Lond.* **188**, 4, 321–330, Apr. 1958.

The use of paraffin wax has been demonstrated by the study of several metal forming operations.

A close correlation has been obtained between theoretical and practical conditions for direct extrusion with lubricated and rough dies. A wide range of practical friction conditions can be obtained by suitable choice of the deforming surfaces. The effects of extrusion temperature and a temperature gradient in the billet are indicated and deformation patterns are shown for tube extrusion.

The reduction/extrusion-load relationship has been obtained in the case of inverted extrusion. The patterns obtained agree with those for lubricated direct extrusion except for conditions of a rough die face and lubricated container wall. A dead zone was observed only in the latter case.

The technique has been extended to the study of the deformation of material passing through a commercial rolling mill.

From authors' summary

736. Ishutkin, V. I., Thermal deformations of cutting tools while machining pig iron (in Russian), *Vestnik Mash.* **37**, 3, 44–46, Mar. 1957.

737. Zotova, L. K., The process of compacting lathe turnings (in Russian), *Sb. statei. Ural'skii politekhn. in-ta* no. 63, 63–69, 1956; *Ref. Zh. Mekh.* no. 4, 1957, Rev. 4752.

738. Takeyama, H., and Usui, E., Machinability of metals (in English), *J. Mech. Lab. Tokyo* **3**, 2, 81–86, 1957.

The object of this report is to find out the relationship between the physical properties of a metal and its machinability in terms of chip formation.

From authors' summary

739. Kennedy, W. B., High-velocity machining with ceramic tools, *Tool Engr.* **41**, 1, 73–80, July 1958.

High cutting speeds mean high tool temperatures and shortened tool life for most cutting tool materials. Ceramic tools are not subject to this destroying heat effect and have superior tool life qualities at high velocities. From author's summary

740. Pines, B. Ia., Sirenko, A. F., and Sukhinin, N. I., Some correlations regarding the mechanical strength of materials obtained by sintering of powdered metals. III: Case when powder mixtures contain easily fusible components, *Soviet Phys.-Tech. Phys.* **2**, 8, 1773–1779, May 1958. [Translated from *Zh. Tekh. Fiz., Akad. Nauk SSSR* **27**, 8, 1904–1911, Aug. 1957 by Amer. Inst. Phys., Inc., New York, N. Y.]

The mechanical strength p of single-phase pressings of the powder of a plastic metal (Cu), heated at a high temperature (1000 C), decreases with increase of porosity over a wide range (0–40%), which is to be expected, considering the weakening of the cross section. At the same time p depends only on the final porosity (obtained after heating) and is independent of the initial porosity (dependent on the compression). For a given final porosity a slight dependence of p on the granular condition of the powder is observed.

An anomalous dependence of the true yield strength on porosity η is observed in the pressings heated at 1000 C and consisting of a mixture of Cu powder with easily fusible additions such as Pb and Sb. The nominal yield strength p' (related to the original cross section of the sample) varies with η in a normal way. In the lightly compressed samples and in the freely poured samples the aforementioned anomalies disappear. The anomalies are caused by the formation, in the presence of easily fusible additions, of large closed pores which become still larger in the course of sintering.

Out of a number of easily fusible additions only Sn increases the mechanical strength of Cu samples at room temperature. The remaining ones lower the mechanical strength. Sn and Pb additions increase the mechanical strength of Cu at the testing temperature of 900 C. The addition of Sb or Bi, however, lowers the mechanical strength. At the same time, the addition of Sn or Pb increases the final elongation prior to rupture. Their action thus consists in (partial) elimination of the brittleness of copper at high temperatures, which brittleness depends on the development of the rupture along the grain boundaries.

From authors' summary

Fracture (Including Fatigue)

(See also Revs. 639, 640, 755, 771, 784, 821)

Book—741. Afanas'ev, N. N., The statistical theory of fatigue resistance in metals (in Russian), Kiev, Izd-vo Akad. Nauk USSR, 1953, 128 pp. + illus., 8r.35k; *Ref. Zh. Mekh.* no. 4, 1957, Rev. 5036.

The statistical theory of fatigue stability is explained; this was developed by the author and published earlier in a series of papers [*Zh. Tekhn. Fiz.*, 1940–1946].

In the forefront of this theory, based on the methods of the theory of probabilities, is found the presentation of the irregular distribution of stresses in the separate crystallites of a polycrystalline body and their verging stability. As shown by the author, the curves of distribution of stability or stressed condition of the crystallites is closely bound up with the curve of statistical tension of a test sample of a given metal.

Given the distribution curve it is possible to calculate the probability of the presence in the parts of the grains individual crystals of stresses higher than the determined level, if the part experiences the effect of the stresses. Further, author arrives at the assumption that in the process of cyclic loading of the part in consequence of cyclic plastic deformation in the separate, unsuitably placed grains, stresses arise in them. At the moment when these stresses attain yield strength a crack appears in the grain, which proceeds to get larger. The calculation of the probability of the presence of such grains leads to the basic relations obtained by the author which characterize the influence of shape and dimensions of the sample, the surface condition, the asymmetrical nature of the cycle, the type of stressed state and its effect on the fatigue resistance. The author introduces a number of experimental data, known earlier, which confirm the equations ob-

tained. There is also a description of the author's experiments carried out to obtain a picture of the micro-structure of the appearance of the fatigue cracks. V. P. Koraev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

742. Harris, W. J., "Size" effects and their possible significance for "non-propagating" cracks in metal fatigue, *Metallurgia, Manchr.* **57,** 342, 193–197, Apr. 1958.

This paper notes the fundamental role played by "size" phenomena throughout the laws of nature. It is suggested that static and fatigue strength of metals and the existence of non-propagating fatigue cracks can be attributed to the existence of characteristic "flaw patterns." Author states that fatigue indicates (as do other theories of yield, creep, etc.) the significance of block structure to explain "size" effect and non-propagating cracks in fatigue. Paper reviews elementary concepts of slip as an introduction to the author's theme.

Paper concerns the relationship of mechanical properties to an intrinsic block structure or "flaw" pattern, but this limiting "size" phenomena of perfect crystal and solids can be of much wider application. Author shows mathematically that notch sensitivity in fatigue is not a material constant, but rather is a "size" effect. He states that a crack commences to propagate when the ratio of strength reduction factor in fatigue to the theoretical stress concentration factor for a notch is slightly greater than a critical value; but as it propagates, local disturbance of the stress field near the tip of the crack shifts this ratio to a value less than the critical, leading to the arrest of the crack.

L. W. Smith, USA

743. Munse, W. H., Fatigue failures in fatigue machines, *Welding J.* **37,** 2, 54s–56s, Feb. 1958.

744. Ivanova, V. S., and Oding, I. A., Metal fatigue resulting from friction of contacting surfaces (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 1, 95–102, Jan. 1957.

745. Chang, T. S., and Kesler, C. E., Static and fatigue strength in shear of beams with tensile reinforcement, *J. Amer. Concr. Inst.* **29,** 12, 1033–1058, June 1958.

Dimensional analysis is employed in deriving expressions for the initial diagonal cracking load and the ultimate strength in shear of simply supported concrete beams with tensile reinforcement only. These expressions, which include size effect, are converted into nomographs for ease of application. This study of static strength includes results from tests of 105 beams, 42 of which were tested by the authors.

Fatigue tests were made on 39 reinforced-concrete beams with tension reinforcement only. These beams were simply supported on a span of 60 in. and loaded at the third points. Statistical studies of the fatigue behavior with regard to initial diagonal cracking and final failure are included.

From authors' summary

746. Nishihara, T., and Yamada, T., Fatigue life of metallic materials under varying repeated stresses of two different stress waves, *Bull. JSME* **1,** 1, 1–6, Jan. 1958.

The fatigue tests under varying repeated stresses, which consisted of two different bending stresses (the first and second stress waves), were carried out by the specially designed testing machine, using notched specimens of 0.22 and 0.61% carbon steels and super duralumin. These test results were compared with the calculated ones which predict the fatigue life of metallic materials subjected to such varying repeated stresses. Authors' conclusions are:

(1) The analytical fatigue life of 0.22% carbon steel and super duralumin under the varying repeated stresses has a good agreement with the test results. (2) In the case of 0.61% carbon steel, the second stress wave has no influence on the fatigue life when the ratio of the second stress wave to the first stress wave, λ, is smaller than about 0.8, and the analytical fatigue lives have a good agreement with the test results only when λ is greater than about 0.8. From authors' summary

747. Hartman, A., and Jacobs, F. A., Research on the static and fatigue strengths of bonded and riveted single lap joints in Clad 2024 and 7075 aluminium alloy at room and elevated temperatures (in English), *Nat. LuchtLab. Amsterdam Rap.* 2041, 10 pp. + 7 tables + 10 figs., Sept. 1957.

The report gives the results of an investigation on the effect of an increase of the temperature from 20 to 150 C on the static tensile shear and fatigue properties at fluctuating tension of 2 row riveted and of Hidux 1033 bonded single lap joints of Clad 2024-T and Clad 7075-T aluminum alloy. The increase of the temperature to 150 C (long soaking times have not been investigated) did not have a noticeable effect on the fatigue properties of the riveted specimens compared to that at room temperature. At 150 C the static strength of light alloy riveted lap joints deteriorates more rapidly than the fatigue properties. The tests on the Hidux bonded specimens showed a noticeable superiority of the bonded Clad 2024-T specimens at 150 C over the bonded Clad 7075-T specimens, both for the static and the fatigue properties. The fatigue properties of the Hidux bonded joints decrease gradually at higher temperatures. At 150 C the bonded lap joints showed a better endurance than the riveted specimens at low stress amplitudes with failure in the metal, the opposite occurred at high stress amplitudes. This transition occurred for the bonded Clad 2024-T specimens at a higher stress amplitude than for the 7075-T specimens. Postcuring at 150 C did not have a noticeable effect on the mechanical properties of the Hidux bonded joints.

From authors' summary

748. Freudenthal, A. M., and Heller, R. A., Cumulative fatigue damage of aircraft structural materials, Part 2: 2024 and 7075 aluminum alloy, additional data and evaluation, WADC TN 55-237 (PB 121909; ASTIA AD 110491), 8 pp. + 4 tables + 10 figs., Oct. 1956.

The object of the investigation is to determine the effect of randomly varying stress-amplitudes representing gust or maneuver load sequences encountered in flight on the fatigue life of 7075 and 2024 aluminum alloys by testing small rotating beam specimens subject to random time series of stress-amplitudes derived from specific frequency distributions of stress-amplitudes. The tests were carried out on specially built random fatigue testing machines of a type developed in the Civil Engineering Research Laboratories of Columbia University.

Most of the test results have been presented in Part 1 of *WADC TN* 55-237. Some recent results are included in the present report. An approximate nonlinear cumulative damage theory based on a thermal mechanism of fatigue supported by a purely statistical approach is developed. The theory approximates test results reasonably well for the unnotched specimens used in the investigation. Its validity, for specimens having stress concentrations, is currently being tested. From authors' summary

749. Yen, C. S., and Whiteson, B. V., Improving fatigue life of formed stainless steel hydraulic tubing by prestressing, *WADC TR* 56-120 (PB 121969), 7 pp. + 2 tables + 18 figs., + 6 appendixes, May 1956.

Tests of formed corrosion-resistant steel tubing conforming to specification MIL-T-6845 were conducted to determine the effect of prestressing on the fatigue life. The forming was controlled so as to have either 5% or 10% of flattening in the formed portion. Prestressing consisted of applying a high hydrostatic pressure to the tubing after forming and before fatigue testing.

It is found that prestressing improves the fatigue life of formed tubing under repeated pressure pulsing within certain limits. Prestressing also produces distortion or permanent deformation of tubing, which can make close tolerance parts unacceptable.

Tests on 5% flattened tubes show the following results: By use of a rigid restraint with a heavy clamp in prestressing, or by subsequent re-forming, the distortion produced by prestressing on close tolerance parts can be prevented or corrected, but the gain in fatigue life due to prestressing is lost. However, a light clamp may be used in prestressing to restrain tube deformation to some extent without appreciably sacrificing the gain in fatigue life.

It is concluded that for formed tubes designed for a given power transmission and to survive one million cycles of constant pressure pulsing, 12 to 35% weight saving can be achieved by prestressing, if prestressing can be applied without rigid restraint and without subsequent rework, and if the maximum pulsing (service) pressure is not over half of the tubing burst pressure.

From authors' summary

750. Litvinov, N. S., The question of standardizing the mechanical properties of structural materials and methods for their determination (in Russian), *Trudī Kuybyshevsk inzh. -stroit. in-ta* no. 3, 200–223, 1956; *Ref. Zh. Mekh.* no. 3, 1957, Rev. 3761.

Experimental Stress Analysis

(See also Revs. 682, 690, 802)

751. Brodie, I., A rapid method for separating the principal stresses in plane photoelasticity, *Brit. J. Appl. Phys.* **9,** 5, 201–203 (Notes and News), May 1958.

A brief study is reported of the accuracy obtained with the well-known method of separating principal stresses by measuring thickness changes, if frozen strains are used. A simple comparator fitted with two dials is proposed. For testing the accuracy, the diametrally loaded circular disk is examined.

E. Monch, Germany

752. Tuzi, Z., Kawata, K., and Hori, I., The photoelastic behaviour of cross-linked polymers, *Brit. J. Appl. Phys.* **9,** 5, 173–177, May 1958.

Authors investigate Young's modulus E and photoelastic properties of several cross-linked polymers (phenolic resin, epoxy resin, diallylphthalate polymer, styrene, divinylbenzene copolymers, styrene-polyester-copolymer) as a function of temperature over a range between 20 and 180 C. In the rubber-like elasticity region at elevated temperature, results are, with one exception, in good agreement with theory, which predicts that E is proportional to the absolute temperature and the strain-optical coefficient is a constant. In styrene-divinylbenzene copolymers the influence of the content of the cross-linking agent is studied. Development of heat edge effect with time is also investigated in the chosen materials.

E. Monch, Germany

753. Grigor'ev, A. M., Bulygin, V. Ya., and Pleschinskii, B. I., Investigation of slopes and drains by the photoelastic method (in Russian), *Tr. Kazansk. khim.-tekh. in-ta* no. 19–20, 145–154, 1955; *Ref. Zh. Mekh.* no. 4, 1957, Rev. 4780.

Data are furnished showing the influence of the geometrical parameters of the slopes and depth of the drains on the character of their stressed state. The investigations were carried out by the optical method. The models for the investigation were made from optically active material of the type IM-44.

Channel slopes were modelled 1000 mm deep with variations of the slope within the limits of 30 to 90° in 5° stages. The relations were obtained for the flow capacity of the channel with changes in its depth at a constant angle of slope $\phi = 45°$. In addition, drains of rectangular section were examined, the parameters of which varied with the height of the channel wall. On the bottom of the drain a circular widened section of 300 mm was modelled. The load was applied in the form of a distributed pressure from a model of a tracked vehicle at different distances from the edge of the drain. The investigations carried out enabled the authors to recommend optimum parameters for the canals and drains for avoiding the danger of caving in due to excavation by the machines working along the track.

B. M. Zuev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

754. Monch, E., Photoelastic investigation of shells by means of a model in whose middle surface a semi-transparent mirror layer is embedded (in English), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **8,** 384–394.

Author's theoretical investigations and experiments (with assistance of Prof. Jira and sponsored by the German government and Research Institute) show that the presented method is valuable for solving practical stress problems in shells. Based on two fringe patterns, the stresses at free boundary can be determined completely, whereas the stresses within the boundaries can be found only with certain approximation. Further research is still necessary to determine if the method can be improved further in respect to complete solution of the general case of biaxial stresses and also of membrane and bending stresses where the principal axes do not coincide. Experimentally, the method is limited to such shell models as can be cast with a semi-transparent mirror layer placed exactly in the middle surface. This is possible with high accuracy in tube models, but in other types of shells it might be difficult. Shells with large curvature are calculated by the Grashof theory of curved bars, which is sufficiently exact up to a ratio of radius of curvature to wall thickness of three. For greater ratios the distribution of stresses can be assumed linear.

J. J. Polivka, USA

755. Grossman, P. U. A., A simple instrument for the periodic application of controlled bi-axial strains, *J. Sci. Instrum.* **35,** 4, 131–134, Apr. 1958.

This instrument produces harmonically varying strains in a thin layer of a test material and controls in two dimensions the frequencies, amplitudes and phases. Weissenberg's method of a flexible boundary is employed to obtain homogeneous strain and a uniform break-up pattern when fatigue failure is approached. The specimen adheres to the surface of a rubber sheet which is extended in two directions by sets of parallel strings fastened to sliding carriages. The carriages follow circular cams, one directly and one through a lever. The cams are interconnected by a chain and rotated in rigidly located bearings by hand or motor. Any phase difference is readily set by positioning the chain wheels, and any ratio of amplitudes by shifting the fulcrum of the lever. A ratio of frequencies can be selected by choosing appropriately sized chain-wheels. To illustrate the applications, the fatigue of powders under various testing conditions is described and the emergent break-up patterns are discussed.

From author's summary

756. Kemp, R. H., Morse, C. R., and Hirschberg, M. H., Application of a high-temperature static strain gage to the measurement of thermal stresses in a turbine stator vane, *NACA TN* 4215, 18 pp. + 1 table + 17 figs., Mar. 1958.

Static high-temperature resistance wire strain gages were used to measure the thermal stresses in a turbine stator vane that was subjected to a temperature variation simulating engine operating conditions. Stresses of −18,000 and −27,000 psi were measured in the leading and trailing edges, respectively. The measured values, in general, compared favorably with analytically determined stresses.

From authors' summary

757. Chaplin, R, Multi-channel slip rings for stress and temperature measurement, *Aero. Res. Counc. Lond. Curr. Pap.* 389, 11 pp. + 7 figs., 1958.

The development of the various types of slip ring are outlined and the design of a brush-and-ring-type of slip ring is discussed in detail.

It is shown that a slip ring unit of this type can be made sufficiently robust to be a permanent part of the instrumentation of any rig. A highly stable contact potential is obtained in this design, making possible stress measurements below ½ ton/sq. in. in steel and temperature measurements with errors of less than 1 C using chromel-alumel thermocouples.

From author's summary

758. Pustynnikov, V. G., Auxiliary instrument for ellipsometers used in the measurement of principal dynamic stresses (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 5, 124–130, May 1956.

Principles of strain-gage application are given, the current of unbalanced bridge being used as measure of deformation. Particulars are provided of equipment which allows measurement of deformations of moving details. The current in bridge circuit is passed for a short interval of time at definite position of detail. Reading of current is taken or automatically recorded and is steady for a frequency of 3–4 or more per second. Calibration for static measurements is done by additional resistances in bridge circuit. A special attachment is used for calibration in the case of dynamically loaded details. Strain gages are placed on beam with known deflections at frequency of tested detail. Calculated strain of beam multiplied by ratio of calibrating and measuring currents gives required strain of tested detail.

The author claims that this method has the advantage of (1) being easily applied for measurements of strain variation in time; (2) giving strain of detail at definite position of it; (3) being used easily outside laboratory; (4) being suitable for measurements of many details at the same time.

W. D. Wilanowski, England

Material Test Techniques

(See also Revs. 728, 743, 750, 752, 778, 786)

759. McHenry, D., and Karni, J., Strength of concrete under combined tensile and compressive stress, *J. Amer. Concr. Inst.* **29,** 10, 829–839, Apr. 1958.

An experimental study of the strength of concrete under combined tensile and compressive stresses was undertaken by loading hollow concrete cylinders to failure. Circumferential tension was developed by internal hydrostatic pressure, and axial compression was produced by end loading in a conventional testing machine. Compressive and tensile strengths were both reduced in the presence of an orthogonal stress of opposite sense.

Test results are presented in terms of principal stresses and of octahedral normal and shearing stresses. In neither case does a simple linear relationship between stresses define the failure conditions satisfactorily throughout the full range from simple tension to simple compression.

From authors' summary

760. Hrennikoff, A., Incremental compression test for cement research, *Proc. Amer. Soc. Civ. Engrs.* **84,** EM 2 (*J. Engng. Mech. Div.*), Pap. 1604, 14 pp., Apr. 1958.

Paper presents a description of a new compression test of cement and concrete which is so conducted that it separates the immediate deformation from creep and by that permits the determination of a number of elastic and inelastic characteristics describing in quantitative manner the stress-strain properties of material and throwing light on the internal mechanism of deformation and failure under load.

From author's summary

761. Maeda, S., and S. Hagihara, The bursting test of turbine generator rotor, Proc. Sixth Japan Nat. Congr. appl. Mech., Univ. of Kyoto, Japan, Oct. 1956, 79–86.

762. Okushima, K., Nagatomi, S., and Okusa, K., Study on the testing method of cemented carbide tool (On the critical value of flank wear), *Bull. JSME* **1,** 1, 79–85, Jan. 1958.

Experiments have revealed that the critical value of flank wear is not always constant, but it should be controlled by the kind of carbide grade, material cut, cutting condition and tool shape. Arranging the experimental data, authors have proposed a summary table of the critical value of flank wear.

From authors' summary

763. Giles, J. H., Jr., and Richmond, J. C., Surface and abrasion tests for porcelain enamels, *Bull. Amer. Ceram. Soc.* **36,** 6, 205–207, June 1957.

An apparatus and test method are described for evaluating the surface and subsurface abrasion resistances of porcelain enamel. Enameled metal specimens are abraded for a designated time with a charge of abrasive, stainless steel balls, and water. The percentage of initial gloss retained after the specified treatment is taken as the index of resistance to surface abrasion, and the inverse rate of weight loss is taken as the index of resistance to subsurface abrasion. Enamels that were ranked in a given order on the basis of resistance to surface abrasion were ranked differently on the basis of resistance to subsurface abrasion. This fact should be considered when deciding which of the two tests to use for a given application.

From authors' summary

764. Harris, J. G., and Crowther, J., The use of ultrasonic testing for the control of quality in the manufacture of aluminum alloys and other non-ferrous materials, *J. Inst. Metals* **86,** 193–206, 1957–58.

The increasing use of ultrasonic testing in final inspection and at earlier stages in processing has led to a marked improvement in the quality of high-strength aluminum alloy plate, extrusions, and forgings. Characteristic defects of cast and wrought material are discussed in relation to their location and evaluation by available methods, and it is pointed out that precise evaluation of defect signals is generally not to be expected. Techniques should be carefully chosen to suit the nature and geometry of the product and the standard of inspection required; automatic equipment now in use offers greater assurance of completeness of inspection. Some experience with copper alloys is also reported.

From authors' summary

765. Shinianskii, L. A., and Solon'ko, V. N., Absorption of ultrasonic vibrations considered as a characteristic of the elastic properties of rubber (in Russian), *Zh. Tekh. Fiz.* **26,** 10, p. 2302, Oct. 1956.

766. Frohmberg, R. P., Nondestructive tests and quality control, *Astronautics* **3,** 7, 32–33, July 1958.

767. Rushchuk, G. M., Neklynkov, I. J., and Levi, A. I., Apparatus for determining the dynamic modulus of elasticity of building materials (in Russian), Moscow, Promstroi izdat, 18 pp. + illus., 1954; *Ref. Zh. Mekh.* no. 2, 1957, Rev. 2581.

The method adopted is founded on the known relation between the modulus of elasticity, the mass of the sample, and its natural oscillation frequency. The test samples were in cross section (4 × 4 cm and 10 × 10 cm) commensurable with a length of 40 cm. In consequence a correcting factor was introduced, taking into ac-

count the influence of the rotation-inertia of the elements of the bar and bending, evoked by the cross-cutting force. The excitation of oscillation and the measurement of the natural oscillation frequencies were carried out with an apparatus designed and erected by the authors—a measurement of the resonance frequencies, using the "Modulemer RPLN." A detailed description is given on its principal features and characteristics. On the basis of numerous tests the relation was established between the modulus of elasticity and the endurance limit (when under compression and deflection) for materials such as cement mixtures and concrete, and especially that with the increase of the modulus of elasticity the endurance increases. By using the method of measuring the modulus of elasticity a study was made of the influence of the hydraulic and surface-active additions on the anti-freeze properties of solutions.

G. P. Mashchaninova

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

768. Savitsky, F. S., and Vandyshev, B. A., The influence of rigidity of the testing machine on the falling section of the tension and bending curve (in Russian), *Zavod. Lab.* **22,** 6, 717–721, 1956; *Ref. Zh. Mekh.* no. 3, 1957, Rev. 3794.

The rigidity values are determined for seven types of testing machines (with mechanical and hydraulic drive), and the influence of the rigidity of the machine on the accuracy of the falling section of the tension and bending curves is investigated.

It is found that, during the process of necking (reduction of area) in tension, the rigidity of the machines investigated fully insures correct registration of the reduction in stress, even for metals giving the steepest falling branch of the curve (copper, mild steel).

Results are given for the static bending of notched test bars in a Gagarin press of variable rigidity (a spring being connected in series with the test bar). The tests show that the falling section of the bending curve, and consequently the work of fracture according to B. A. Drozdovsky [*Zavod. Lab.* 1946, **12,** (4–5), 489–499], greatly depends on the relationship between the rigidity of the testing machine and the loss of strength of the test sample. It is therefore concluded that with an absolutely rigid machine it is in principle possible to obtain a force diagram for any process of crack development (as far as $P = 0$), and the rate of propagation of the crack can be controlled. Yu. I. Likhachev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

769. Saillard, Y., "Tor-60" twisted steel bars. Experimental investigation (in French), *Publ. Int. Assn. Bridge Struct. Engng.* **17,** 173–196, 1957.

For several years past, the Chambre Syndicale des Constructeurs en Ciment Armé de France (French Association of Reinforced Concrete Constructors) has been undertaking research work for the purpose of comparing the properties in regard to bonding and cracking of reinforcement bars with various profiles, and of determining the optimum profile for steel bars having a tensile strength of 60 kg/mm^2.

A theoretical analysis of these problems was given in a previous paper presented to the 5th Congress of the International Association for Bridge and Structural Engineering held at Lisbon in 1956 (see Preliminary Publication, **8,** pp. 815–840). This analysis is completed by a report on the corresponding tests given in the present publication.

The first series of tests enabled a comparison to be made between three French prototypes of twisted steel bars with profiles determined a priori, on theoretical grounds, and the profiles employed at the present time for Austrian twisted steel bars (Tor-60), Swiss twisted steel bars (Tor-60), and Swedish indented steel bars (Kam-60). These tests, which were carried out on 3 series of 12 beams, with various percentages of reinforcement, demonstrated the equivalence of the prototype profile with transverse lugs, and the Swiss profile with longitudinal ribs. However, this latter profile, which has the advantage of being rolled more easily and with less damage to the steel, appears, finally, to be the most satisfactory.

A second series of tests enabled a comparison to be made of cracking in full-size elements of engineering structures reinforced with smooth steel bars and with Tor-40, Tor-60, and Tor-80 twisted steel bars, with or without ribs. The interpretation of these tests, in accordance with the theory of Peter Brice, shows very satisfactory agreement with the experimental results.

In conclusion, it would seem that the form coefficients applicable to the calculation of cracking under bending or tensile stresses, for the various profiles of steel bars, are appreciably lower than corresponding form coefficients applicable for the calculation of anchorage and bedding. For the calculation of cracking, the form coefficients determined experimentally hardly appear to exceed a value of 1.00 to 1.20 for ordinary smooth steel bars, and a value of 1.60 to 1.70 for the various steel bars with high bonding power. Furthermore, additional comparative tests carried out subsequently have confirmed these values and support author's opinion. From author's summary

Properties of Engineering Materials

(See also Revs. 638, 645, 646, 647, 655, 666, 731, 738, 750, 759, 760, 817, 823, 1100)

770. Fuchs, M. Ya., Slonovsky, N. V., and Lupilov, L. I., A radiographic investigation of the phenomena accompanying the permanent elongation of steel at elevated temperatures (in Russian), *Fiz. metallov i metallovdeniye* **2,** 2, 328–338, 1956; *Ref. Zh. Mekh.* no. 3, 1957, Rev. 3753.

The radiographic examination of the steels St.20 and 35XHM has disclosed a substantial difference in the resolution of coherent regions and the magnitudes of the microstresses, in dependence on the rate of deformation and the temperature.

The radiograms were evaluated separately to determine the cohesion of the disperse regions and microstresses by three different methods, using, among others, harmonic analysis.

Authors are of the opinion that, for the steels investigated, the totality of the data obtained leads to the conclusion that the decrease in strength under prolonged stress at elevated temperature may be explained by resolution (fractionation) of the coherent regions with a low value of the microstresses.

I. V. Vikker

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

771. Barducci, I., Anelastic behaviour of solids at high temperatures (in Italian), *Ric. Sci.* **28,** 2, 313–322, Feb. 1958.

After briefly recalling the anelastic behavior of solids at high temperatures, as well as the theoretical interpretations suggested by Bordoni and Nuovo and by Mason, author discusses some experimental results which contribute to the determination of the law of dependence of the logarithmic decrement of the oscillations upon frequency and temperature.

It is confirmed that the decrement increases following an exponetial law as a function of 1/absolute temperature, just as expected by both theories mentioned; however, as to the dependence on frequency, neither theory seems to offer sufficiently approximated results. From the discussion of the test results some elements appear which, if confirmed by further tests, might eventually lead to a more satisfactory interpretation.

From author's summary

772. Gordon, S. A., Simon, R., and Archbach, W. P., Materials-property-design criteria for metals, Part 4: Elastic moduli: their determination and limits of application, WADC TR 55-150 (ASTIA AD 110475), 18 pp., Oct. 1956.

A study was made of the modulus of elasticity at elevated temperatures for several materials as it is derived from the conventional stress-strain curve and as it is derived from the determination of the velocity of propagation of elastic waves. The two methods of determination give modulus values which agree closely in regions of low stress and where time effects are unimportant. At higher stress levels, where the stress-strain relationships are not linear and where time effects are important, the moduli determined by the two methods do not agree, the dynamic modulus being higher than the statically determined modulus.

The differences determined for the magnesium alloy AZ-31 and for the aluminum alloy 2024-T4 for various temperatures are discussed with respect to their applicability to air-frame design.

From authors' summary

773. Ryabinin, Yu. N., Volumetric elasticity of the elements at extremely high pressures (in Russian), *Fiz. metallov i metallovedenie* **2**, 2, 225-236, 1956; *Ref. Zh. Mekh.* no. 4, 1957, Rev. 5004.

On the basis of Bridgeman's experimental data obtained by means of a method developed by Kornfeld, an investigation was made of the relation of the modulus of all-sided compression K to pressure for the elements in D. I. Mendeleev's periodic system. For the elements not having polymorphous mutations in the range of pressures being examined, this relation, as is known, is described by the equation $K = n(p + \pi)$, where p is the pressure, while n and π are constants of the material. Authors show that in the elements experiencing polymorphous conversion in the presence of the appropriate pressure, the modulus K may increase, decrease, or remain unchanged, during which its abrupt alteration may not be accompanied by an alteration in volume. Thanks to this circumstance, the analysis of the relation $K = f(p)$ disclosed, in a number of elements, changes in elasticity which, possibly, may be proof of the presence of mutations previously unnoticed. The permanent equations of condition state and the equation $K = f(p)$ were calculated for more than fifty elements, and the atomic volumes of the elements were computed; it was shown that with increase in pressure they decrease in conformity with the periodic structure of the electronic pattern of the atoms; at a pressure of 500,000 kg/cm^2 the atomic volumes should already have a weak periodic relation to the atomic number. Two tables are published giving the values for n and π for 44 elements.

B. S. Ioffe

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

774. Klier, E. P., Feola, N., Viggiano, A., and Weiss, V., The properties of constructional metals as a function of temperature and strain rate in torsion, WADC TR 56-216 (PB 121912; ASTIA AD 110559), 37 pp. + 125 figs. + 30 tables, Nov. 1956.

Seven structural metals have been tested in torsion at four strain rates and at selected testing temperatures. The torque-twist relationships have been determined at the three lowest strain rates.

The experimental results confirm the trends established by Work and Dolan. These trends have been shown to arise from changes in the torque-twist diagrams for the respective materials in strain-rate intervals which are essentially unchanged for the different metals and which center on a strain rate of about 0.1 in./in./sec.

Both solid and tubular specimens have been tested and for the tubular specimens the normal strain rate modification of the modulus of rupture is observed at high strain rates. Differences in the trends of the data for the solid and hollow specimens are attributed to the action of the heat sink which the core of the solid specimen constitutes.

It has been possible to explain the several types of properties versus strain-rate curves by means of alterations in the torque-twist curve arising from strain hardening, temperature increase in the specimen due to plastic working, and to strain-rate modification of the yield strength.

From authors' summary

775. Denny, J. P., and Kendall, L. F., Jr., Uncommon engineering metals, ASME-Machine Design Conf., Chicago, Ill., Apr. 1958. Pap. no. 58-MD-4, 9 pp.

Design engineers, faced with demands for devices to function in increasingly severe environments, can solve many of their problems by using uncommon materials. To bring engineers and designers up to date on some uncommon metals, a review is presented of zirconium, hafnium, vanadium, columbium, tantalum, chromium, and rhenium. The following information is discussed for each metal: Availability, cost, physical and mechanical properties, fabrication, and applications.

From authors' summary

Book—776. Rostoker, W., The metallurgy of vanadium, New York, John Wiley & Sons, Inc., 1958, ix + 185 pp. $8.50.

Book contains a compact, comprehensive treatment drawn from the literature and from unpublished data of several research organizations. Chapter headings include (1) Extractive metallurgy of V, (2) Physical properties of V, (3) Constitution of V-alloy systems, (4) Mechanical properties of V, (5) Mechanical properties of V alloys, (6) Technology [forming, plating, welding, etc.] of V, (7) Oxidation of V and associated topics, (8) Corrosion and embrittlement of V, (9) Metallography of V and its alloys, (10) V as an alloy addition. A very adequate bibliography is appended to each chapter.

In reviewer's opinion the book is clearly written, and the data, covering the present-day state of the art, well presented. It should be a worthwhile reference tool for anyone investigating properties of new materials for new or special uses.

S. Goodman, USA

777. Mizonov, E. D., The influence of longitudinal displacement of a textile yarn on its tension during spinning (in Russian), *Tekstiln. prom. st.* no. 8, p. 27, 1956; *Ref. Zh. Mekh.* no. 3, 1957, Rev. 3776.

In the normal working of a spinning machine two adjacent roves are spun with opposite twist, the ends of the two yarns passing through the guides being knotted and thrown over a sheave acting on a spring. The latter is connected with a transmitter, influencing the balancing of a Wheatstone bridge. The current in the bridge diagonals is amplified and applied to an oscillograph for a record on photographic paper (a nine-loop, universal oscillograph 9-50-302 of Siemens & Halske was used). The author has found that the tension of the yarn depends on whether it is moving along its direction of spinning or not—a question which has hitherto been regarded as debatable.

A. N. Gerasimov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

778. Parikh, N. M., Effect of atmosphere on surface tension of glass, *J. Amer. Ceram. Soc.* **41**, 1, 18-22, Jan. 1958.

The surface tension of a commercial soda-lime-silica glass was measured in various atmospheres in the temperature range 500 to 700 C. The method of fiber elongation was used and its usefulness is illustrated. Water vapor was found to exhibit the most pronounced effect, causing a lowering from 315 to 205 dynes cm^{-1} for a vapor pressure of 16 mm Hg.

From author's summary

779. Russell, E. W., Transparent materials for aircraft—a review, *AGARD Rep.* 160, 11 pp. + 4 tables, Nov. 1957.

Developments in transparent materials for aircraft are reviewed. Extensive work has been done on the organic plastics, and offers improved performance and reliability, but with only limited advances in high-temperature performance. As alternative materials the inorganic glasses compel attention and are shown to suffer from several limitations both for windscreens and canopies. Possible lines of development are briefly indicated.

From author's summary

780. Hahner, C. H., and Kerper, M. J., Inorganic transparencies for aircraft enclosures, *AGARD Rep.* 161, 12 pp. + 3 tables + 7 figs., Nov. 1957.

Present and projected designs of aircraft impose very severe requirements on the transparent materials used in construction. Aerodynamic heating results in temperatures above those at which present-day plastic materials can be used. Glass is the best glazing material available but complete information on its properties under the contemplated conditions of use are not yet available. This report is a review of the available information on glass and contains a description of work now being done under the sponsorship of the Wright Air Development Center to obtain additional information on a few selected glasses that are believed to be most suitable for use in aircraft. The glasses selected for study are ones that can be made in the form of polished plate glass of the required sizes. From authors' summary

781. Lioznyanskaya, S. G., The technological principles of airstream cooling in the annealing of glass (in Russian), *Trudi Vses. n. in-ta stekla* no. 35, 71–77, 1955; *Ref. Zh. Mekh.* no. 3, 1957, Ref. 3170.

Book—782. Laeis, M. E., Injection molding of plastics [Der Spritzguss thermoplastischer Massen], Munchen, Carl Hanser Verlag, 1956, 295 pp. 29. DM

Book gives a review of the history, development, and present state of the technic of injection molding of plastics. Special emphasis is placed on the economic aspects of the injection molding industry. A. Phillips, USA

783. Dyment, J., and Ziebland, H., The tensile properties of some plastics at low temperatures, *J. Appl. Chem.* **8,** 4, 203–206, Apr. 1958.

Tensile tests have been carried out on polytetrafluoroethylene, polycaprolactam, polyvinyl chloride and polytrifluoromonochloroethylene at four temperature levels ranging from +20 to −196 C.

The tensile strength of polytetrafluoroethylene increased from 1.44×10^3 lb/sq in. at room temperature to 13.8×10^3 lb/sq in. at −196 C, while the tensile strengths of polycaprolactam, polyvinyl chloride and polytetrafluoroethylene correspondingly increased from 9.5×10^3, 7.7×10^3 and 6.3×10^3 lb/sq in. to 27.9×10^3, 19.7×10^3 and 16.2×10^3 lb/sq in., respectively. The moduli of elasticity were similarly increased.

From authors' summary

784. Baccaredda, M., Bordoni, P. G., Butta, E., and Charlesby, A., Elastic and anelastic behaviour of some irradiated polymers (in Italian), *Pubbl. Fac. Ing., Univ. Pisa (16a)* no. 775, 11 pp., 1956.

The effect of radiation on polymers is to produce crosslinking between molecules, degradation by random fracture of the main chain and destruction of crystallinity. Changes in mechanical properties have been determined measuring Young's modulus and damping with a dynamic method in three different types of polymers, namely polystyrene, polymethylmethacrylate and polyethylene. Polystyrene is radiation resistant, but can be crosslinked by sufficiently high radiation doses. A small increase in the elastic modulus and in the resonance coefficient and in the second-order transition point has been found, even for radiation doses corresponding to about three crosslinked units per one hundred monomer units.

Polymethylmethacrylate degrades very readily under radiation, and the side chains are also fragmented. At sufficiently high temperatures, the gaseous fragments congregate to form bubbles within the specimen. At temperatures below those required for bubble formation, the gaseous products are held dispersed within the specimen. The molecular weight changes, and the dispersion of these products has no appreciable effect on the elastic modulus and damping, but the material behaves like a glass, showing conchoidal fracture.

In polyethylene the effect of irradiation is to produce both crosslinking and destruction of crystallinity, at temperatures below the melting point. Minimum values in density and elastic modulus and maximum values in damping at room temperature are observed for a critical radiation dose. The corresponding quasi-amorphous crosslinked material shows rubberlike elastic behavior. Higher crosslinked materials have a higher elastic modulus than the rubberlike theoretical values. Less irradiated materials present also higher elastic modulus and lower damping; this is probably due to the overlapping of crystallites, which form a very rigid framework.

A second-order transition point, which may be attributed to the transition of crystallites to the amorphous state, is observed in the irradiated polyethylenes.

A minimum in the transition temperature is found for the material irradiated with the critical radiation dose; rubberlike behavior is also observed in polyethylenes irradiated with a lower radiation dose than the critical value at temperature above the transition point. From authors' summary

785. Reznikovskii, M. M., Vostroknutov, E. G., and Priss, L. S., Methodical questions in the study of the stability of rubber with stresses varying with time (in Russian), Ageing and fatigue in rubbers and the improvement of their stability, Leningrad, Goskhimizdat, 1955, 76–88; *Ref. Zh. Mekh.* no. 4, 1957, Rev. 5063.

Authors put forward a classification of the basic systems for testing rubbers for dynamic fatigue. All the systems used can be referred to one of four groups of testing proposed in the classification.

Investigations are made of a new apparatus for the dynamic testing of rubbers which permits the examination of not only the fatigue strength, characterized by the number of cycles performed before rupture, but also of the fatigue itself, characterized by the changes in the properties of the material in the process of multiple loading at short intervals of time. (1) Apparatus permitting the application of any one of the dynamic systems with an asymmetrical loading cycle: Tests on this apparatus are carried out in conditions of homogeneous tension and in accordance with the harmonic principle of alternation of stress and deformation. (2) Apparatus for the observation of fatigue and fatigue strength in rubbers during a symmetrical loading cycle (the mean values of the stress and the deformation are equal to zero), which permits the determination, together with the fatigue strength, of the dynamical modulus and losses per loading cycle in the samples subjected to bending deformation. L. S. Bryukhanova

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

786. Mattyasovszky-Zsolnay, L., Mechanical strength of porcelain, *J. Amer. Ceram. Soc.* **40,** 9, 299–306, Sept. 1957.

Author treats the porcelain strength problem with respect to the different composition of glassy phase versus mullite phase. Critical observations are based upon the mullite hypothesis of strength and author suggests that the strength is strongly influenced by prestressing phenomena within the glassy phase. From batch contents of variegated clay, feldspar and quartz compositions treated

in different firing schedules, full-scale solid-core insulators and standard test pieces of small size were subjected to hardness tests and tensile strength tests. In addition, quartz grain size studies and investigations on the effects of fluxes on quartz dissolution were undertaken. From the test results it was found that certain prestressing effects increasing the total strength could be calculated from the difference between the coefficients of thermal expansion of the core material and those of the shell material of the insulators. Reviewer believes that this calculation is based on rather uncertain considerations of the relation between true core area and true shell area of the transverse section of the insulator rod, but the tendency of the prestressing influence might be adequately described. R. Nilson, Sweden

787. Topping, A. D., The use of experimental constants in the application of theories of strength to rock, Proc. Second Midwestern Conf. Solid Mech., Purdue Univ., Sept. 1955, 178–193.

Investigation of the magnitudes of specific experimental constants reveals a significant discrepancy between triaxial test results reported in the literature and proposed yield criteria applicable to materials not equally strong in tension and compression (e.g., Mohr's theory). Examination of the octahedral stress components at the beginning of yielding suggests generalizations of these criteria which permit satisfactory description of the test data. The new criteria are found to be adaptable to fracture by translating them into terms of strains. The method of determining specific values for analytical use is illustrated.

From author's summary

Structures: Simple

(See also Revs. 665, 674, 686, 704, 720, 749, 798)

Book—788. Nervi, P. L., Structures (Translated from Italian by Giuseppina and Mario Salvadori), New York, F. W. Dodge Corporation, 1956, ix + 118 pp. $6.95.

Book describes, in a most unique and interesting way, the pertinent factors which influence the development of the art of construction. Extensive use is made of photographs and drawings to graphically illustrate the author's works as a master builder over a 30-year period.

As an architect-engineer-contractor, author describes the important role of the client, the governing economic considerations in building construction, and the need for a more balanced academic and artistic training for the progressive building designer.

In a rather nontechnical way, the book describes the important structural characteristics of reinforced concrete and its imperfect elastic behavior; the applications of "ferro-cements" to naval architecture and civil engineering construction; the advantages and applications of prefabricated constructions; the use of experimental model analysis for determining the stress distribution in highly indeterminate structures, not amenable to theoretical analysis. Finally, the high structural efficiency and bright future of thin-shell construction is discussed.

Book should provide most interesting reading for progressive architects, engineers, and builders who are actively engaged in reinforced-concrete construction. M. M. Lemcoe, USA

789. Vlasov, V. Z., Theory of prestressed hollow beams, plates and shells (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 5, 70–84, May 1956.

Starting with the general case, author concentrates on cases representing reinforced-concrete problems.

In the case of a beam under transverse bending and torsion, proof is given that, of the three differential equations of equilibrium, only the torsional one is affected by prestressing. The differential equation remains unchanged when GJ (torsional stiffness) is replaced by $G\bar{J}$ (reduced torsional stiffness). Buckling problems are affected in exactly the same manner.

Initial thermal stresses are similarly dealt with, but the differential equation of torsional equilibrium is different—except in one particular case—as it also includes the first derivative of the angle of twist (both open and closed thin-walled profiles are considered).

Finally, the case of prestressed plates is treated where the prestressing member is either in the middle or off center.

J. Solvey, Australia

790. Dirkes, W. E., High-strength structural sandwich construction, ASME-Machine Design Engineering Conf., Chicago, Ill., Apr. 1958. Pap. 58-MD-10, 8 pp.

Detailed materials strength properties, design criteria, fabrication, and repair techniques are available in the publications referenced. This paper presents a general review of sandwich construction to illustrate what it is, types of configurations most widely used, and a brief discussion of some critical fabrication and design problems. From author's summary

791. Stevens, G. H., Mechanical properties of plastic laminates *For. Prod. Lab. Rep., U. S. Dept. Agric.* 1820-D (supplement), 7 pp. + 4 tables + 3 figs., Jan. 1958.

Report presents the results of a series of tension, compression, and bending tests of a parallel-laminated silicone laminate reinforced with 181 glass fabric. The data supplement those of *Forest Products Laboratory Reports* 1820, 1820-A, 1820-B, and 1820-C of the same title, in which results of tests of polyester, phenolic, and epoxy laminates were given.

Tension tests were made after normal conditioning; compression and flexural tests were made after both normal and wet conditioning. From the results of the tension tests, the panel shear strength was calculated. The average strength properties are presented both in tables and as curves.

In general, the mechanical properties of the silicone laminate at room temperature were lower in value than those of comparable polyester, phenolic, and epoxy laminates. In tension at 0 degrees, however, the mechanical properties of the silicone laminate were approximately the same values as those of polyester and phenolic laminates. From author's summary

792. Kornishin, M. S., Influence of unsymmetrical irregularity on the deformation of a sloping panel when loaded transversely (in Russian), *Izv. Kazansk. Fil. Akad. Nauk SSSR, Ser. Fiz.-Matem. i Tekhn. N.* no. 10, 63–68, 1956; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5881.

The dependence of pressure on the bending of a cylindrical panel is determined; the panel is freely supported on all its sides and has a given sinusoidal original irregularity of shape. The problem is solved, in a nonlinear arrangement, by the integration of three equations of equilibrium in displacements using the Bubnov-Galerkin method. The solution is given in a clear form for a panel with a length equal to twice the width; in particular, a determination is made of the original minimum value of the curvature at which there is an emergence of a nonsymmetrical form of loss of stability of the panel without original bonding. It remains vague why this value of curvature, obtained with the ratio of the sides 0.5, is brought in as a general criterion of the slope of the panel.

N. A. Alfutov

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

793. Spirin, G. M., Determination of the stresses by means of the network method in bodies with different elastic constants (plane problem) (in Russian), *Izv. In-ta Gidrol. i Gidrotekhn. Akad. Nauk. USSR* **14**, 21, 96–105, 1956; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5871.

A method is put forward for the determination of stresses in compound singly-connected bodies having different elastic constants and weights by volume. The conditions of equality of the relative transformations along the line of contact of the separate parts of the body are expressed through the stress function and the relation of the elastic constants; the volumetric forces are carried out to the contour. The problem is solved by the network method; in so doing supplementary unknowns appear in the values of the stress function and its first derivatives in the network connections lying on the line of contact. A numerical example is given and a comparison made. P. M. Varvak

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

794. Rassudov, V. M., Deformation of inclined envelopes supported by stiffening ribs (in Russian), *Ucb. zap. Saratovsk. in-ta* **52,** 51–91, 1956; *Ref. Zh. Mekb.* no. 4, 1957, Rev. 4609.

An investigation of the deformation of inclined isotropic envelopes, including a zero Gauss curvature, strengthened by rigid ribs. A variation method is used to obtain the basic differential equations and ratios of the theory of inclined envelopes having the given plan and rigid ribs.

The derivation is given of the basic differential equations and boundary conditions on the rigid ribs in conditions of slight deformation. The system of equations is reduced first of all to a system of two equations for the stress and bending functions, and then to one equation of the 8th degree of the form

$$\left(\nabla^2\nabla^2\nabla^2\nabla^2 + \frac{Eb}{D}\nabla_k^2\nabla_k^2\right)\Phi_i = \frac{q_i}{D}\left(D = \frac{Eb^3}{12(1-\nu^2)}\right) \qquad [1]$$

$$\nabla^2 = \frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2} \qquad \nabla_k^2 = \frac{\partial}{R_2\partial x^2} + \frac{\partial}{R_1\partial y^2}$$

where E is Young's modulus, D the cylindrical rigidity, ν Poisson's ratio, b is thickness of the envelope, R_1 and R_2 the main radii of curvature, q_i the load distributed over the sections of the envelope, and Φ_i the required function by means of which all the required values are expressed.

A solution of equation [1] is given for an inclined envelope, two edges of which are open and two others secured as desired. The solution is in the form of series

$$\Phi_i = \sum_{k=1} \Phi_{ik}(x) \sin \frac{k\pi}{b} y \qquad [2]$$

Next, the deformation of an inclined arch strengthened by rectilinear rigid ribs is examined. Further, integration is performed of integral equations of an inclined cylindrical arch having one rectilinear rigid rib under the action of a normal pressure uniformly distributed in specific conditions on the edges of the envelope. A detailed examination is made of the case when all the edges of the envelope are supported by hinges. The numerical value of the bending and of the normal stresses and bending moments for certain values of the ratio g/b, where g is the lift of the envelope at the center, are given. The method described for solving the problem of deformation of an inclined cylindrical arch supported at all four sides and strengthened by rectilinear rigid ribs reduces it to solution of a nonhomogeneous linear algebraic system of four equations with four unknowns.

E. F. Burmistrov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

795. Rinne, J. E., Earthquake design criteria for stack-like structures, *Proc. Amer. Soc. Civ. Engrs.* **84,** ST4 (*J. Struct. Div.*), Pap. 1696, 26 pp., July 1958.

Paper indicates the response of uniform and tapered stacks and stack-like structures to earthquake ground motion, develops some criteria for shears and moments for design, and compares these with criteria suggested or specified by others.

From author's summary

796. Blume, J., Structural dynamics in earthquake-resistant design, *Proc. Amer. Soc. Civ. Engrs.* **84,** ST4 (*J. Struct. Div.*), Pap. 1695, 46 pp., July 1958.

Recent research efforts utilizing high-speed digital computers and electric analogs have indicated vast differences between design and code values for structures and their actual earthquake shears and behavior. This paper attempts to reconcile these differences with the aid of comprehensive structural and dynamic analyses and research efforts on two office buildings—one the traditional filler-wall type and the other a modern glass-wall structure. Included are strengths, rigidities, and energy-absorption values for the former building under various distortions up to failure and also the results of a comprehensive series of analog tests for the modern 20-story structure using four complete earthquake records with 16 various systems of damping and rigidity values. Certain inconsistencies and pitfalls in present-day design practice are demonstrated, and new considerations are suggested for resisting the occasional but extreme energy releases of nature.

From author's summary

797. Latham, G. R., Welded spiral case construction procedures, *Trans. ASME* **80,** 5, 1145–1146, July 1958.

Structures: Composite

(See also Revs. 779, 780, 1046)

Book—798. Pugsley, A., The theory of suspension bridges, New York, St. Martin's Press, 1957, vii + 136 pp. $10.

The distinguished author of this small volume gives a concise but remarkably inclusive account of the various analytical methods for the calculation of suspension bridges. After a historical introduction, two chapters are devoted to the deformation of the unstiffened cable under various conditions. The next chapter deals with the Rankine theory which is of considerable historical importance. This is followed by two chapters outlining the elastic (linear) and the deformation (nonlinear) theories of suspension bridges. Three different approaches for the linearization of the deflection theory are presented in the next chapter, including the flexibility coefficient method originated by the author. The subjects of the next two chapters are the Fourier series approach and various approximate methods of analysis, including one proposed by the author reducing the original problem to that of beams on elastic foundation. The last two chapters are devoted to a discussion of the natural modes of vibration and the oscillation and dynamic instability of suspension bridges under lateral wind loads.

The book fills a long-felt need in the English literature on this subject. It is very readable, covers the essential features of the subject, and is highly recommended to any student or practitioner of the science of structural mechanics.

M. Hetenyi, USA

799. Szabo, J., Matrix computation of the influence surfaces for four-girder bridges (in Hungarian), *Mélyépitéstudományi Szemle* **7,** 7/8, 228–232, July/Aug. 1957.

Author presents applications of results previously published by him and by E. Egervary [AMR **8** (1955), Rev. 3594 and **9** (1956), Rev. 3885]. A method is described whereby the shear and moment influence surfaces belonging to the main (longitudinal) girders and to the cross trusses can be obtained. A specific numerical example is worked out for a span of four main and three cross members.

While the method (not derived, only described in this paper) is based on the specific resolution of quadratic matrices [AMR **9** (1956), Rev. 3884], its application requires knowledge of elementary matrix operations (addition and multiplication) only.

Paper is clearly written and easy to follow. Its usefulness is pronounced for the reader who prefers mechanical and dogmatic formula application to basic understanding.

V. G. Szebehely, USA

800. Heilig, R., Calculations of beams with varying cross-section heights and disk-type arches (in German), *Bautechnik* **34,** 11, 432–436, Nov. 1957.

Paper gives solution for disks with variable height, such as in arch-like bridges. Compared with correct solution for wedge-like disks, approximations hold reasonably well for total angles up to 35°.

Reviewer believes paper of interest for calculation of this type of structure, and the difference from the usual beam theory is clearly demonstrated. A. Selberg, Norway

801. Wah, T., Distribution of loads in two types of railway bridges (in English), *Publ. Int. Assn. Bridge Struct. Engng.* **17,** 241–268, 1957.

The question of the distribution of train loads in the direction parallel to traffic ("longitudinal" distribution) and in the direction perpendicular to traffic ("lateral" distribution) arises in the design of certain types of railroad bridges. The problems involved in this question are analyzed mathematically for open-deck bridges, and formulas are derived for the longitudinal and lateral distribution of loads. Approximate solutions are also devised wherever feasible in order to furnish simple formulas which may be of use in design. Some of the formulas are translated into tables given in the appendix.

From author's summary by K. Angervo, Finland

802. Krishna, J., Slabs constrained on three edges, *J. Instn. Engrs. India* **38,** 9 (part I), 801–814, May 1958.

Problem relates to stresses in a vertical rectangular slab such as the side of a reservoir, loaded by hydrostatic pressure increasing from zero at the top free edge. Author derives simple empirical formulas for maximum bending moments in horizontal and vertical directions. Moments are taken in terms of constants together with dimensionally suitable combination of liquid density and slab dimensions. Constants are simple functions of slab proportions evaluated by experimental measurement of strains and displacements on a small cast araldite container, cut to three successive wall depths.

Well-known basic theory is indicated but not discussed in any detail. C. E. Turner, England

803. Hoff, N. J., Bloom, M., Pohle, F. V., Oliver, H., Mirsky, I., Berks, W. I., Chwick, A., MacLean, W. R., and Lederman, S., Theory and experiment in the solution of structural problems of supersonic aircraft, WADC TR 55-291 (PB 121326), xiv + 355 pp., Mar. 1956.

Progress in the solution of structural problems of supersonic aircraft will depend upon theoretical investigations which have been based upon the results of experiments. The twelve chapters of this report were originally published separately to answer various questions of a theoretical and experimental nature. The report consists of three parts: Part I: Aerodynamic heating and its effects. Part II: The effect of rapid creep. Part III: Theory and practice of induction heating.

From authors' summary

804. Topping, A. D., Behavior of materials under combined stresses in pressurized structures, *Aero. Engng. Rev.* **16,** 2, 56–59, Feb. 1957.

Taking a recent paper by Zaustin as a point of departure, author suggests two approaches to minimum-weight design of pressurized aircraft structures: The first is based on experience with rock, the second on experience with fabric.

From author's summary

Machine Elements and Machine Design

(See also Rev. 614)

Book—805. Linder, W., Gears II: Skew spur and bevel gears, helical gears [Zahnrader II: Stirn-und Kegelrader mit schragen Zahnen Schraubgetriebe], Berlin, Springer-Verlag, 1957, vii + 132 pp. DM 18.

Although this is the second volume of a German standard work on gearings, it can be read and used on its own if the principles of gears and gearings are known. Book deals only with gears having skew teeth to provide smoother running. Theory, calculation and manufacturing are amply described. In the last part of the book the various methods and instruments for the dimensional control of manufactured gears are discussed. Book seems primarily intended for designers and manufacturers. It is profusely illustrated with a great number of fine drawings and pictures and provides a good survey of modern gear-cutting techniques and machines. R. G. Boiten, Holland

806. Krakinovskii, L. M., Gearing strength calculations (in Russian), *Vestnik Mash.* **37,** 3, 18–19, Mar. 1957.

807. Czitary, E., Behavior of a cable riding on an elastically coated roller (in French), *Ann. Ponts Chauss.* **127,** 6, 795–820, Nov.-Dec. 1957.

It is common practice to deflect or bend a cable by means of a roller. An elastic coating in the groove of the roller, e.g. a rubber coating, can reduce the curvature of the cable. Paper presents detailed calculations of effect of coating on curvature and stress of cable including conditions which must be satisfied by the coating. Originally by E. Czitary [AMR **10** (1957), Rev. 1748], paper was translated into French by L. Lehanneur. Translator added a section which covers an instance not considered by Czitary, and also presents a simpler method of computing curvature.

J. Duffy, USA

808. Whalen, J. J., Leakage and elastic characteristics of compressed asbestos sheet packing, ASME Semiann. Meet., Detroit, Mich., June 1958. Pap. 58-SA-28, 27 pp.

Paper consists of a study of the leakage and elastic characteristics of compressed asbestos sheet packing. Variables investigated were bolt load, gasket width, gasket thickness, and flange surface finish. Leakage data were correlated with respect to the m-value. It was found that the m-value is not constant, and typical curves were derived from various leakage pressures and area ratios. This area ratio is the ratio of internal area to gasket area. The effect of gasket thickness and flange surface finish on the m-value is discussed also. The stress-strain characteristics of a typical compressed asbestos sheet were studied. From the stress-strain and leakage data, new design equations based on elastic theory were derived to predict the required total bolt area necessary to maintain joint tightness.

From author's summary

809. Glushchenko, I. P., Dependence of the rigidity of a plate-like hauling chain on its pitch (in Russian), *Nauch. zap. L'vovsk politekhn. in-ta* no. 17, 47–58, 1953; *Ref. Zh. Mekh.* no. 4, 1957, Rev. 4974.

Theoretical calculations are given for determining the static rigidity of driving and hauling chains on the basis of investigated

deformations of the individual structural components of the links; the relationship between the pitch of the chain and its rigidity is established.

F. M. Dimentberg

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

810. Kremenshtein, L. I., Construction of the function $\omega(\phi)$ for steady motion without investigation of the stage of acceleration of the engine (in Russian), *Trudi Kievsk. tekhnol. in-ta legkoi prom-sti* no. 7, 150–160, 1955; *Ref. Zh. Mekh.* no. 4, 1957, Rev. 3947.

Author examines the approximation method for determining the steady motion of an engine, which does not require investigation of the stage of acceleration of the engine. The method is explained by application to the case when the excess reduced moment is a function of the angle of turn of the leading member. If the moving moment is a decreasing function of the angular velocity the method in question can also be used, but it requires examination of the process of acceleration by indirect means.

S. G. Kislitsyn

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

811. Golubentsev, A. N., Equation for the dynamics of machines with consideration of the elasticity of their components (in Russian), Calculations, construction and testing of mining machines, Vol. 2, Moscow, Ugletekhizdat, 1955, 432–451; *Ref. Zh. Mekh.* no. 4, 1957, Rev. 4966.

812. Ogurechnikov, A. N., Dynamic rigidity of rotating shafts (in Russian), *Trudi Mosk. aviats. in-ta* no. 55, 93–135, 1956; *Ref. Zh. Mekh.* no. 4, 1957, Rev. 4681.

Fastening and Joining Methods

(See also Rev. 747)

813. Nandeeswaraiya, N. S., Stresses in bolted gasketed joints—1. Analytical study, *J. Instn. Engrs. India* **38,** 3(part 2), 261–276, Nov. 1957.

Paper develops equations to compute the required initial bolt stress for bolted gasketed joints. The stress is based on the creep and sealant characteristics of the gasket, the external load on the joint, and the expected life of the joint.

H. H. Dixon, USA

814. Bland, J., Parrish, C. B., and Wheeler, R. C., Casting-weldments in a petroleum refinery, ASME-AWS Joint Metals Engng. Conf., St. Louis, Mo., Apr. 1958. Pap. 58-MET-5, 12 pp.

Several typical applications of casting-weldments in a petroleum refinery are described. Results of some limited studies of the weldability characteristics of low and intermediate chromium-molybdenum alloy-steel castings are discussed. Castings which meet specification requirements for chemistry and tensile properties, in addition to being virtually free from casting defects, are satisfactory components of petroleum-refining equipment and process lines. Certain maintenance and repair problems associated with casting-weldments are discussed.

From authors' summary

815. Chapin, N. A., Soldan, C. H., and Songer, L. W., Welding low-alloy steel castings for high-pressure and high-temperature service, ASME-AWS Joint Metals Engng. Conf., St. Louis, Mo., Apr. 1958. Pap. 58-MET-4, 11 pp.

The service requirements of modern steam turbine-generator equipment necessitate that casting-weldment components have high strength and maximum reliability. Procedures used in processing low-alloy steel components for this type of service are described. The use of manual submerged-arc welding has improved the quality and increased the weld-disposition rates. Pre- and postweld heat-treatments and the interrelation of castings and fabrication design are discussed. Also, the importance of complete records and good quality-control practices is pointed out.

From authors' summary

816. Parker, E. R., Stress relieving of weldments, *Welding J.* **36,** 10, 433s–440s, Oct. 1957.

Residual stresses are those present in a solid body when no external forces are acting upon the body or they may be considered as the stresses that remain in a structure as result of localized plastic deformation. Residual stresses introduced by welding are caused by localized heating associated with the welding process and, to a lesser degree, by shrinkage of the weld metal. Such residual stresses may be large in magnitude, frequently reaching the yield point of the material. In some instances they have been directly responsible for the fracturing of welded assemblies.

In a butt weld of unrestrained flat plates, the residual stress in the direction parallel to the weld generally is much greater than in the direction transverse to the weld, although transverse stresses may approach the yield point in large thick plates joined by multipass welds.

The relation of residual stress to brittle fracture is still a matter of controversy but experimental evidence appears to indicate that residual stresses have little effect unless defects such as a crack are present.

Reaction stresses occur in structures that are welded under restrained conditions. "Residual stresses" are generally considered to be highly localized and associated with steep stress gradients as distinguished from "reaction stresses" which are uniform over relatively long distances. Reaction stresses can be relaxed by separating two parts of a structure by a single cut whereas residual stresses cannot. Reaction stresses in welded parts can initiate brittle fracture.

Residual compressive stresses are considered to improve fatigue life but it has not been proved that residual tensile stresses are deleterious. Limited evidence indicates that ordinarily welding stresses have little effect on fatigue behavior.

Although reports of fractures in service due to welding stresses are rare, such failures that have occurred have indicated that residual stresses in conjunction with other factors such as low temperature, thermal stresses, excessive cold work and mechanical defects can be a contributing factor.

Welding stresses may be relieved by either of two basic methods: by thermal stress relieving or by mechanical stretching. Thermal treatment is a very effective means for removing welding stresses. Mechanical stress relieving is accomplished by stretching plastically the regions that are under tension. A variation of this process is "low-temperature stress relieving" which involves heating two bands adjacent to and parallel with the weld to a controlled low temperature (about 350 F). This process is finding considerable use on large simple structures.

A number of factors influence the relief of residual stress. Among these are initial stress level, time, temperature, composition of steel, and microstructure. Section size is also important because it determines the length of soaking time required to insure that all parts of a structure are thoroughly heated. Preheat also influences the residual stress pattern and hence the stress-relieving process.

From author's summary

817. Green, W. L., Hamad, M. F., and McCauley, R. B., The effects of porosity on mild-steel welds, *Weld. Res. Suppl.* **37,** 5, 206-s–209-s, May 1958.

Results of tensile, bending and impact tests show that the cross section of the welds tested could be reduced by porosity up

to about 7% without materially changing the mechanical properties measured. From authors' summary

818. Long, J. V., and Cremer, G. D., High-temperature corrosion-resistant brazing, *Astronautics* **3,** 8, 28–29, Aug. 1958.

819. Huschke, E. G., Jr., and Hoppin, G. S., II, High-temperature vacuum brazing of jet-engine materials, *Weld. Res. Suppl.* **37,** 5, 233-s–240-s, May 1958.

820. Perry, H. A., How to calculate stresses in adhesive joints, *Prod. Engng.* **29,** 27, 64–67, July 1958.

Structural adhesives are getting stronger and so is the interest in this method of joining load-bearing members. Author analyzes six basic joints and shows how to calculate stress concentrations in each. From author's summary

821. Hartman, A., The effect on the static and fatigue properties of riveted light alloy lap joints of reinforcing the critical section with thin adhesive bonded sheets (in English), *Nat. LuchtLab. Amsterdam Rap.* NLL-TN M.2047, 13 pp. + 3 tables + 27 figs., Mar. 1958.

Static tests and fatigue tests in fluctuating tension have been executed on 2-row riveted lap joints in clad 2024-T and clad 7075-T aluminum alloy. The effect was studied of reinforcing the critical section over the rivets by 2 or 3 adhesive-bonded strips to half the sheet thickness. The static strength increased almost to the tensile strength of the sheet material. The fatigue strength was noticeably increased by reinforcing with 2 strips; a further increase of the number of reinforcing strips had a negligible effect. The probability of failure of the specimens at the outer edge of the first reinforcing strip was greatly increased by a high stress amplitude and by the use of 3 reinforcing strips instead of 2. The 2024-T clad specimens proved to be superior at low stress amplitudes. The effect on the fatigue strength of the 2-rivet patterns used was small. A calculation of the bending moments at the critical sections proved to be very useful to explain the results. From author's summary

822. Slaughter, G. M., Partiarca, P., and Manly, W. D., Bonding of cermet-valve components to metals, *Welding J.* **37,** 6, 249-s–254-s, June 1958.

823. Suchsland, O., On the penetration of glue in wood gluing and the significance of the penetration depth for the strength of the glue joints (in Swedish), *Sven. TraforskInst. Medd.* 95 B, 101–108, 1958.

The penetration of a waterproof cold glue into coniferous wood has been investigated on microscopic sections by incident light. The studies revealed the interesting fact that even an abundant glue amount does not necessarily penetrate the whole surface in every case. An increase of the grain angle causes the glue to flow preferably into the springwood cells. When end grained wood was glued the degree of penetration reached only 60%. The effect of the penetration of the glue on the tensile strength of wood was examined on parallel glued pine veneers. Gluing and relatively high penetration depth led to an increase of the tensile strength. The penetration depth of hot-glued pine and birch specimens could be reduced to a minimum by varying the amount of glue applied. The results of the shear tests and of the microscopic measurements of the penetration depth showed no relationship between the penetration depth and the strength of the joint. Concluding, the paper discusses the gluing of end grained wood and deals with the reasons to which the difficulties occuring in this exceptional case are traceable. From author's summary

Hydraulics

(See also Revs. 599, 612, 753, 858, 859, 860, 923, 966, 1076, 1092)

Book—824. Mostkow, M. A., Handbook of hydraulics [Handbuch der Hydraulik], Berlin, (VEB) Verlag Technik, 1956, 491 pp.

This practical handbook of hydraulics, translated from the Russian into German, consists mostly of tables of empirical coefficients, with a minimum of text material. Although entire field of hydraulics is treated, author considers book as supplementary to another handbook of hydraulics, by Pawlowski. Coverage of the free overfall is very thorough. Several figures seem to have been copied without acknowledgement from "Engineering hydraulics," edited by Rouse. L. Landweber, USA

825. Gerashchenko, O. A., and Nazarchuk, M. M., On the wettability of surfaces in connection with the solution of hydrodynamical problems, *Soviet Phys.-Tech. Phys.* **2,** 12, p. 2596, Dec. 1957. (Translation from *Zh. Tekh. Fiz., Akad. Nauk SSSR* **27,** 12, p. 2797, July 1958 by Amer. Inst. Phys., New York, N.Y.)

826. Naudascher, E., Discharge and dynamic forces on high pressure sluice gates (in German), *Bauingenieur* **32,** 11, 428–439, Nov. 1957.

Author analyses which forces may be expected on a regulating gate at the entrance of a high-pressure conduit and how these forces are influenced by the shape of the structure.

By means of classical methods he attempts to give an accurate computation procedure for these forces, leaving the possible vibrations out of consideration. From well-known momentum and energy considerations, discharges and pressures are deduced. The many unavoidable empirical constants necessitate, however, some experience or the aid of a model.

Details about the pressure distribution around the gate are derived from a two-dimensional potential flow net with the assumption that this is possible in the region where the flow is accelerated. Estimates of the location of the points of flow separation improve the applicability of the method. The places where cavitation may occur are indicated too.

Author claims that he is able to compute the total force on the gate within 3% accuracy. Comparisons with measurements in models, clearly illustrated in diagrams, show where the computed pressures deviate from the measured ones.

Three examples are given: the vertical gate closing against the face of a step in the bottom, the same closing on top of the step and the inclined gate, both with various shapes of the lower edge of the gate. H. J. Schoemaker, Holland

827. Rasumsvskaia, M. R., On wave formation in spillways (in Russian), *Gidrotekh. Stroit.* **26,** 8, 45–48, Aug. 1957.

828. Burkov, A. F., and Kind, Yu. V., Peculiarities of the hydraulics of high-pressure locks (in Russian), *Izv. Vses. n.-i. in-ta gidrotekh.* **54,** 98–105, 1955; *Ref. Zh. Mekh.* no. 4, 1957, Rev. 4246.

The well-known difficulties connected with the necessity of combating an unpermissible reduction of the hydrodynamic pressure behind the floodgates of the galleries for filling high-pressure navigable locks are noted, and the arrangement of the successive placing of two floodgates, which, dividing the pressure of the lock in two, are able to remove the pressure reduction in question, is examined. The authors note works by B. D. Kachanovskii [Hydraulics of navigable locks, Rechizdate, 1951, p. 222] and A. S. Abelev devoted to this problem.

Short explanations of the hydraulic calculation of a feed system having two successively disposed locks are given, and the results of the experimental investigations of this system applied to the

conditions of a navigable lock having a pressure of 33 m are indicated. On the basis of their investigations authors recommend opening of the lower floodgate a little before the upper floodgate.

M. E. Fakgorovich

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

829. Fomichev, M. S., Investigation of the pulsations of hydrodynamic pressure by means of models (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 11, 116–119, Nov. 1956.

Author presents results of pressure-fluctuation measurements in the settling basin downstream of a weir by means of 1/5 and 1/10-scale models as well as in full-scale flow. Similarity rules are given for these pressures and related phenomena and are borne out by the experimental results. Author observes that when aeration occurred in full scale it also occurred on the models.

F. W. Diederich, USA

830. Gardel, A., Simplified calculations of surge tanks (in German), *Schweiz. Bauztg.* **75,** 31, 485–489, Aug. 1957.

This is a summary of the last chapter of author's treatise on surge chamber calculation ["Chambres d'équilibre," Lausanne, 1956]. Assuming that the maximum (or minimum) surge is attained immediately and remains constant (max. surge = M), author develops a simplified surge theory; surge tank volume is easily estimated for partial or total gate opening or closing and can be taken from two general diagrams (traced in relative values). Author explains how method is to be modified to take into account the real type and shape of the surge tank (variable cross section, restricted orifice, differential surge tank, etc.).

C. Jaeger, England

831. Skladnev, M. F., The boundaries of surface-bottom conditions in the linking of levels of locks which end in a down-stream terrace (in Russian), *Izv. Vses. n.-i. in-ta gidrotekh.* **55,** 75–95, 1956; *Ref. Zh. Mekh.* no. 4, 1957, Rev. 4281.

Results are given of laboratory tests of the boundaries of surface conditions behind a spillway which has a horizontal projection with a terrace. The tests were performed in conditions of a two-dimensional plane in a trough of width 0.302 m, length 10 m, and height 0.62 m. The flow to a horizontal projection (dam) was effected from under a board. The length of the projection was (2.5–5.0) b_1 where b_1 represents the vertical dimension of the orifice of the slit under the board. An investigation was made of the minimum height of the terrace necessary for the formation of a nonsubmerged surface jump for the assumed length of the projection. Particular attention was devoted to the boundaries of the surface-bottom conditions in zones of nonsubmerged and submerged surfaces jumps.

By means of tests these ranges of values were found: $a/b_1 = 0.5 - 16$; $t/b_1 = 1.5 - 40$; and $v^2/gb_1 = 1 - 80$, where a is the height of the terrace, b_1 the thickness of the jet on the projection, t the depth in the lower level. Empirical equations are given for some boundaries of the conditions. A sample calculation is given.

The question of the stability of the surface conditions with raising and lowering of the level of the lower level in the zone of the submerged surface jump was not examined in the tests. Therefore a part of the range of the discharges and depths investigated, for which the author gives surface conditions as stable, will actually be in the zone of unsteady conditions, the lower boundary of which is not given by the author. In the sample calculation the length of the projection is not indicated. In figure 13 the length of the projection is equal to zero, which causes an abrupt reduction in the stability of the surface conditions and disagreement between the calculated and the natural data.

N. N. Belyashevskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

832. Skladnev, M. F., The length of the eddy section of surface and surface-bottom hydraulic jumps (in Russian), *Izv. Vses. n.-i. in-ta gidrotekh.* **55,** 176–187, 1956; *Ref. Zh. Mekh.* no. 4, 1957, Rev. 4282.

On the basis of laboratory tests empirical relationships are given in graphical and analytical form for determining the length of rolling (eddy) zones in surface jumps of various types found behind spillway plane which end in a horizontal projection with a terrace.

Data relating to the experimental arrangement and to the range of the hydraulic values investigated which characterize the state of the flow on the projection and in the lower level are given in author's previous paper [see preceding review].

N. N. Belyashevskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

833. Stommel, H., Arons, A. B., and Faller, A. J., Some examples of stationary planetary flow patterns in bounded basins, *Tellus* **10,** 2, 179–187, May 1958.

A simple regime of fluid flow is defined. This regime can occur in a homogeneous layer of fluid (1) of uniform depth on a rotating sphere and bounded by meridional barriers, (2) of uniform depth on a beta plane and bounded by barriers running north-south, (3) of radially nonuniform depth on a rotating plane and bounded by radial barriers. The essential elements defining the regime are: (a) the flow in the whole layer is steady and geostrophic except and only (b) at the western boundary where a narrow, intense western boundary current is permitted to depart markedly from geostrophy, and (c) the system, which would otherwise be at rest, is driven by a distribution of sources and sinks of fluid (this includes driving agents such as the wind, which can be expressed in terms of source and sink distributions).

Predictions concerning patterns of flow have been deduced from the defined regime and verified experimentally on a rotating model of type (3). Certain results obtained were by no means intuitively obvious from *a priori* considerations.

From authors' summary

834. Vallentine, H. R., Flow in rectangular channels with lateral constriction plates (in French), *Houille Blanche* **13,** 1, 75–84, Jan.-Feb. 1958.

Characteristics of flow in a rectangular channel with sharp-edged lateral constriction plates placed symmetrically, normal to the flow, are examined in a small tilting channel. The flow rate Q is related to the upstream depth y_1 by means of a discharge equation $Q = Cby_1^{3/2}$, where b is the width of opening and C is an experimental coefficient which depends upon the constriction ratio and the Froude number of the unconstricted flow. The values of C are established for Froude numbers up to 2.1 and constriction ratios up to 95%.

The conditions under which insertion of constriction plates produces an increase in upstream depth are investigated and the extent of the increase is evaluated. From author's summary

835. Budavari, K., and Kovacs, G., Design discharge in drainage channels allowing for endurance (in Hungarian), *Hidrológiai Közlöny* **37,** 1, 16–22, Jan.-Mar. 1957.

836. Bretting, A. E., Stable channels, *Acta Polyt. Scandinavica* no. 245, 115 pp. + 11 figs., 1958.

Channel design involves the determination of a cross section stable against erosion and sedimentation for a given discharge. Author considers stability against scour in a channel of cohesionless bottom material having a known angle of internal friction and a limiting tractive force.

On the assumption that the shear is proportional to the distance from the bottom to the water surface, measured normal to the bot-

tom, and that the grains are acted upon by a hydrodynamic lift which is proportional to the shear, the differential equation of the bottom form is established and integrated numerically. Assuming further that the velocity distribution is logarithmic and that the equilibrium profile will have a minimum area, a definite solution is found. The relation between the mean and maximum velocities is also determined.

Theoretical profiles are compared with results of three model tests, and fair agreement is found. Reviewer believes these results to be inconclusive and that the validity of some of the assumptions is open to question. W. DeLapp, USA

837. Viti, M., Contribution to the study of unsteady flow in channels (in Italian), *Ingegnere* **31,** 10, 903–914, Oct. 1957.

Study of the differential equations of unsteady flow in channels uses the method of characteristic lines. In a somewhat artful way, two new independent variables are assumed, whose physical meaning does not seem too clear; they lead nevertheless to an effective simplification of the calculation for the integration of the system. A numerical calculation, effected in a hypothetical situation particularly simple, shows the details of the procedure. Paper contains also a discussion of the possible solutions of the system.

D. Citrini, Italy

838. Petersen, M. S., McGee, H. C., and Fenwick, G. B., Hydraulic effects of model distortion; triangular-flume study of distortion effects, *Wuys. Exp. Sta. Res. Rep.* 2–1, 22 pp. + 4 tables + 15 plates + 3 appendixes, Sept. 1957.

An investigation of the hydraulic effects of the various types and degrees of model distortion was undertaken to evaluate such effects, with the ultimate aim of establishing limits of permissible distortion for the various types of models. Idealized triangular-flume studies were successful in establishing quantitatively the influence of channel shape on the channel resistance function for the cases studied. Continuation of studies of this type should prove of scientific and practical value in the planning of model experiments and the interpretation of results, and should permit tabulation of parameters which would establish limits and effects of distortion for various types of models. However, the field would have to be studied much more extensively before such parameters could be determined. Time and economic factors indicated the desirability of discontinuing the idealized studies in favor of a more direct and practical approach to the study.

From authors' summary

839. Ambartsumyan, G. A., Determination of the hydrodynamic pressure on a plane board due to flow from under the board (in Russian), *Izv. Akad. Nauk ArmSSR, Ser. fiz.-matem., estestv. i tekh. nauk* **7,** 6, 99–108, 1954; *Ref. Zh. Mekh.* no. 4, 1957, Rev. 4271.

Examination of the case of free flow of a fluid from under a plane vertical board in a prismatic channel of rectangular section the bottom of which is slightly inclined. The problem is posed of determining the theoretical value of the hydrodynamic force acting on the board. For solution of the problem joint use is made of the law of the quantity of motion and of the Bernouilli theorem, i.e., the law of kinetic energy.

Assuming the values of the coefficient of the quantity of motion, of the coefficient of kinetic energy and of the coefficient of velocity to be equal to unity, author obtains a hydrodynamic force equal to

$$P_b = \frac{\gamma}{2}(H - b)\left(H - 3b + \frac{2v_1^2}{g}\right)$$

where H and b are the depths before the board and in the compressed section respectively, v_1 is the approach velocity. Introducing $b = a$ (where a is the height of the orifice) and excluding v_1, the author then arrives at the formula

$$P_b = \frac{\gamma H^2}{2}(1 - k)\left(1 - 3k + 4\frac{k^2}{1 + k}\right)$$

where $k = \epsilon a/H$.

For verification of the formulas obtained in the hydrotechnical laboratory of the Arm NIIG and M tests were made. The force acting on the board was determined from the line of pressure drawn from the indications of the piezometers. There was good agreement between theoretical and experimental data. A comparison was also made of author's data with the laboratory data of N. K. Girinskii [*Gidrotekhn. str-vo* no. 10, 1934].

O. F. Vasil'ev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

840. Balanin, P. D., Laboratory tests of the phenomenon of flow about a dike (in Russian), *Trudi Akad. rechnogo transporta* no. 2, 178–197, 1953; *Ref. Zh. Mekh.* no. 4, 1957, Rev. 4287.

Paper is devoted to laboratory tests of flow about a dike, using models with a mobile bottom. The trough in which the tests were made had a length of 6.25 m, a width of 1.07 m, and a height of 0.18 m. The tests were made at a flow of 16.2 litres/sec at a speed of 15 cm/sec, a depth of flow of 10 cm, and a Reynolds number of 11,520.

The basic series of tests was made at an angle between the transverse walls of the dike (wings) and of the longitudinal wall of the trough of 30–90°, at a ratio of the width in the compressed part to the whole width of the trough inside equal to 0.35–0.80, and at lengths of the longitudinal wall of the dike up to 1.45 m.

For protection of the upstream angle of the dikes against erosion the following tests were made: the use of blank spurs of rectilinear and curvilinear shape; the use of permeable spurs; changing the shape of the upstream angle of the dikes.

The tests of this series were made with one type of dike. The angle between the transverse wall of the dike and the longitudinal wall was 90°.

The boundaries of breakaway of the jet, the shape of the vortex, jet and stagnant regions were studied, the values of the surface and bottom velocities were measured and the values and character of the deformation of the channel were determined.

V. A. Shaumyan and Kh. S. Shapiro

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

841. Ripp, M. I., and Fishelevich, D. I., Calculation of hydraulic pressure losses in washing shafts by a clay solution (in Russian), *Izv. Dnepropetr. gorn. in-ta* **23,** 75–80, 1955; *Ref. Zh. Mekh.* no. 4, 1957, Rev. 4239.

A comparison was made of the empirical formulas for determination of the pressure losses in boring pipes and an annular space; certain inaccuracies are disclosed in K. A. Tsarevich's formula [N. I. Kulichikhin, B. I. Vozdvizhenskii, Razvedochnoe burenie, Gosgeolizdat, 1949] for pipes and an annular space.

B. S. Filatov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

842. Chernikin, V. I., Joint pumping of petroleum and water along pipe-lines (in Russian), *Trudi Mosk. neft. in-ta* no. 17, 101–111, 1956; *Ref. Zh. Mekh.* no. 4, 1957, Rev. 4245.

Explanation of a suggestion for the hydraulic calculation of spiral pipe lines used for pumping heavy petroleum along pipes together with a small quantity of water. These pipe lines have a helical rifling on the inner surface. In other cases the rifling is replaced by a wire placed in spiral fashion inside the pipe. When

the water and petroleum are pumped along the pipe together an aqueous film which sharply decreases the hydraulic resistance is formed on its inner surface.

Author examines the case when, in accordance with observations, turbulent conditions occur in the annular flow of water, while the flow of petroleum takes place in laminar conditions.

Assuming a number of simplifying assumptions in respect to both flows, author derives relationships for determining the thickness of the aqueous layer and for calculating the hydraulic deviation at given rates of flow of water and petroleum.

Considerations regarding the conditions of stability of the aqueous film are also elucidated.

A numerical example of the calculation of the pumping of the petroleum in a concrete spiral pipe line is given as well as a comparison of the results of the calculation with the data of actual observations made during the operation of this pipe line. Based on the analysis of this calculation, conclusions which are of practical interest are drawn.

V. A. Arkhangel'skii
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

843. Plotnikov, N. A., The theoretical determination of pressure in a compressed drop liquid (in Russian), Vopr. izucheniya podzem. vod i inzh.-geol. protsessov, Moscow, Akad, Nauk SSSR, 1955, 136–139; *Ref. Zh. Mekh.* no. 4, 1957, Rev. 4208.

An examination of the pressure change in a fluid in relation to the depth, having regard to the compressibility of a drop fluid. A corresponding calculation formula is given for isothermal conditions. Author points out that, disregarding the influence of compressibility, an error of 0.2% in determining the pressure is possible in the case of a pillar of water of 1000 m.

G. L. Grodzovskii
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

844. Novikov, A. G., Determination of head losses on trash racks (in Russian), *Gidrotekh. Stroit.* **26,** 10, 50–51, Oct. 1957.

845. Hazard, H. R., Gluck, F., and Tate, R. W., Erosion in turbojet fuel nozzles, *Mech. Engng., N.Y.* **80,** 10, 58–60, Oct. 1958.

In turbojet fuel nozzles erosion by cavitation is promoted by the high temperature of the air (up to 1200 F) and of the fuel (up to 400 F), whereby the metering characteristics and spray pattern may be impaired, resulting in unsatisfactory performance. In present erosion study, laboratory procedure simulating engine conditions was developed, and a radiochemical technique was perfected whereby the nozzle parts were irradiated by exposure for 13 days in a nuclear reactor, eroded material recovered and measured by radiochemical analysis capable of determining wear rates down to 1 microgram per hour. Burning of the atomized fuel was prevented by pressurizing the spray chamber with nitrogen. Testing equipment is illustrated and described; typical erosion on nozzle tip and swirl is shown; chart of rate of wear is given. Erosion resistance of several fuel injector designs was evaluated under extreme environmental conditions (up to fuel pressure of 500 psi, temperature of 500 F, and nozzle discharge pressure of 200 psi). This is a typical example of the new measuring methods of extreme sensitivity which has been made possible by the application of radioactivity.

K. J. DeJuhasz, Germany

846. Chudinov, S. D., The hydrodynamic characteristics of a cavitating wing of finite span (in Russian), *Trudi Tallinsk. politekh. in-ta* no. 61 A, 3–16, 1955; *Ref. Zh. Mekh.* no. 4, 1957, Rev. 4043.

A method of calculating the induced drag of a cavitating wing is proposed.

Use is made of Prandtl's arrangement in which the motion of a liquid in planes perpendicular to the direction of flight is considered to coincide with plane-parallel flows caused by symmetrical forward motion of a plate. Use is made of the coefficients of associated mass of the plate in this motion and, by applying the theorem of the amount of motion and the theorem of energy, the induced velocities are calculated. At the same time the impulse and energy losses are disregarded.

In the conditions indicated, the relations between the lift, induced drag and induced velocities coincide with the ordinary relationships of the approximate theory of a wing of finite span in a solid flow.

Examination of the relationship of the lift coefficient to the angle of attack of a cavitating wing for various lengths shows that the influence of cavitation is shown more strongly in the case of increase of the lengths.

D. A. Efros
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Incompressible Flow

(See also Revs. 642, 781, 808, 894, 895, 916, 927, 944, 955, 988, 1091)

847. Armstrong, A. H., An extension of the hydrodynamic source-sink method for axisymmetric bodies, *Aero. Res. Counc. Lond. Rep. Mem.* 3020, 14 pp. + 1 table + 5 figs., 1957.

The coordinate along the axis of symmetry is allowed to be complex. It is shown that conjugate complex sources at conjugate complex points on the axis of symmetry produce real flow fields which are exactly equivalent to source and vortex ring singularities. Consequently the flow past *any* axisymmetric body can be represented by a suitable distribution of these complex sources at complex points on the axis. Simple sufficient conditions on the body shape are found in order that these distributions should be replaceable by real distributions along the real axis. The method avoids the cumbersome complete elliptic integrals associated with ring singularities and introduces instead only singularities of the square-root type. Applications are made to flows past spheroids and paraboloids.

A. F. Pillow, Australia

848. Shulikovsky, V. I., Determination of the two-dimensional motion of a fluid from given values of the modulus, divergence and rotation of its velocity (in Russian), *Uch. zap. Kazanskogo in-ta* no. 1, 20–21, 1956; *Ref. Zh. Mekh.* no. 3, 1957, Rev. 3018.

849. Perekhal'skii, V. S., Division of a flow with branching of a channel (in Russian), *Trudi Akad. rechnogo transporta* no. 2, 214–223, 1953; *Ref. Zh. Mekh.* no. 4, 1957, Rev. 4246.

850. Wu, C. S., and Hayes, W. D., Crocco's vorticity law in a non-uniform material, *Quart. appl. Math.* **16,** 1, 81–82 (Notes), Apr. 1958.

851. Weber, J., The calculation of the pressure distribution on the surface of thick cambered wings and the design of wings with given pressure distribution, *Aero. Res. Counc. Lond. Rep. Mem.* 3026, 36 pp. + 38 tables + 8 figs., 1957.

This is a further contribution to the extensive literature on design of two-dimensional airfoils in incompressible flow. It covers thick cambered wings of any given camber line of large or moderate aspect ratio. Special attention is given to the neighborhood of the tips and the wing center sections; the pressure distribution near the latter is governed by an integral equation of Carleman type. The methods developed are applied to the design of wings with specific camber lines and chordwise velocity distributions.

M. Holt, USA

852. Khaskind, M. D., Three-dimensional streamline flow around slender bodies (in Russian), *Prikl. Mat. Mekh.* **20,** 3, 203–210, 1956 (Translated from Russian by M. D. Friedman, Inc., 67 Reservoir St., Needham Heights, Mass., K-165, 12 pp.)

The singular integrodifferential equation for a cambered lifting line in incompressible fluid is formulated, first, with gravity neglected. Gravity is then taken into account and the generalized lifting-line equation is solved. This solution is applied to the problem of flow past a vertical semiring and flow past a vertical wing in a heavy fluid. M. Holt, USA

853. Batchelor, G. K., On steady laminar flow with closed streamlines at large Reynolds number, *J. Fluid Mech.* **1,** 2, 177–190, July 1956.

The steady laminar motion of incompressible fluids with small viscosity is investigated. The viscous forces are considered small compared to the pressure forces everywhere (except at certain boundaries) and the Reynolds number is large enough for the thicknesses of the viscous layers to be small compared with characteristic lengths.

An integral condition for the vorticity distribution is derived for arbitrarily small viscosity, stating that the contribution from viscous forces to the rate of change of circulation round any streamline is zero. This integral condition is combined with the inviscid flow equations for two-dimensional closed flows and for rotationally symmetric flows. It is shown that the sum of the velocity and pressure heads (the Bernoulli constant) varies linearly with the stream function and that the rate of change of vorticity is not influenced anywhere by viscosity effects.

This very readable paper is one of the classical contributions to present-day hydrodynamics.

V. G. Szebehely, USA

854. Napolitano, L. G., Some remarks on the solution of a system of equations occurring in laminar mixing with axial pressure gradients, Polyt. Inst. Brooklyn, Aero. Lab. Rep. 393, 14 pp. + 2 figs., Sept. 1957.

An analysis is made of a fifth-order system of equations from the point of view of obtaining solutions by means of high-speed computing machines. Two possible methods of solution are outlined; an iteration method and a method considering the solution as an "initial value" problem. In this last case special attention is paid to reduce the indeterminacy of the solution.

J. A. Businger, USA

855. Birkhoff, G., and Carter, D., Rising plane bubbles, *J. Math. Mech.* **6,** 6, 769–779, Nov. 1957.

Authors treat the plane flow problem of an isolated bubble rising steadily under the influence of gravity in an infinitely long vertical tube of incompressible, inviscid fluid. Adapting methods of Levi-Civita and Villat, they use techniques of conformal mapping to reduce this free boundary problem to a nonlinear integral equation. The integral equation is attacked numerically by a procedure based on equal-spaced interpolation and truncation of certain Fourier series. However, in contrast with situation without gravity, the convergence is found to be not really satisfactory. Several unexpected difficulties are brought to light and discussed in the hope that they may be resolved by further analysis.

P. R. Garabedian, USA

856. Bankoff, S. G., Entrapment of gas in the spreading of a liquid over a rough surface, *AIChE J.* **4,** 1, 24–26, Mar. 1958.

857. Watabe, K., On fluid friction of rotational rough disc in rough vessel, *Bull. JSME* **1,** 69–74, Jan. 1958.

858. Payne, R. B., A numerical method for calculating the starting and perturbation of a two-dimensional jet at low Reynolds number, *Aero. Res. Counc. Lond. Rep. Mem.* 3047, 39 pp. + 20 graphs + 11 figs., 1958.

The jet emerges from a slit in a plane wall. Source strength increases linearly from zero to certain value, then remains constant. Motion is computed for equal time steps on Manchester I computer. Vorticity is carried along by the velocity, and the subsequent velocity is computed by integrating the effect of the new vorticity field. Motion begins as potential flow and, to satisfy condition of no slip at the boundary, vorticity is introduced there. This vorticity is conducted into the body of the fluid by viscosity. Distribution of vorticity and velocity are shown in diagrams for several low Reynolds numbers. Front of jet has two whirls of opposite rotation whose vorticity is gradually conducted into the surroundings.

Several sources of error are thoroughly investigated; these are mainly results of computing techniques, not of physical aspects of the method. Method is a powerful one, but suitable only for automatic high-speed machines.

R. S. Scorer, England

859. Vereshchagin, L. F., Semerchan, A. A., and Filler, F. M., Investigating water jets discharged through nozzles at up to 2000 atmosphere pressure (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 1, 57–60, Jan. 1957.

860. Polikovskii, M. V., Designing inlets of ejectors (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 1, 61–69, Jan. 1957.

Using the velocity profile known to exist around a jet discharging into stagnant incompressible fluid, author uses continuity and momentum considerations to effect a stepwise integration along the flow. He thus calculates the spread of the central jet till it embraces the whole flow through the ejector, with subsequent smoothing of flow in the throat.

Regions of local flow reversal are dealt with, and the onset of cavitation briefly considered.

The paper contains graphs of several integrals occurring in the calculations, and would probably be of interest to design engineers. A. H. Armstrong, England

861. Patraulea, N. N., Theoretical contributions to the study of the jet flap (in French), 9th Congrès Intern. Mécan Appl., Univ. Bruxelles, 1957; **2,** 457–463.

Results of theory previously developed by the author are presented under a more general form of a linear integral equation giving velocities in the jet field. This is followed by a new method based on trigonometric series. Since this series is rapidly converging, advantages for numerical computations are obtained. Finally, the problem of a primary flow within an expanding tube formed by a high-speed jet is considered. However, due to the complexity of rigorous treatment of this case, approximation is made by considering flow between two parallel infinite aspect ratio plates with jet flaps. This reviewer finds that lack of definition of some symbols creates continuous stumbling block in reading this paper. W. Z. Stepniewski, USA

862. McGregor, D. M., and Etkin, B., Investigation of the fluctuation pressures on a circular cylinder in an air-stream, *Phys. Fluids* **1,** 2, 162–164, Mar.-Apr. 1958.

Compressible Flow (Continuum and Noncontinuum Flow)

(See also Revs. 611, 718, 719, 803, 866, 889, 890, 891, 906, 916, 918, 920, 940, 954, 972, 1031)

863. Ginevskii, A. S., Energetic characteristics of subsonic diffusion channels (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekn. Nauk* no. 3, 152–154, 1956; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5433.

The energy characteristics are examined in the subsonic continuous flow of a viscous gas in a flat or in an axisymmetrical diffusion channel. The characteristics of the channel are determined on the basis of the averaging by mass of the magnitude of entropy in the various sections of the channel. Simple relations were obtained for the coefficient of loss due to the increase of entropy, and also for the mean loss due to full pressure.

G. L. Grodzovskii
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

864. Nonweiler, T. R. F., The sonic flow about some symmetric half-bodies, *J. Fluid Mech.* **4,** 2, 140–148, June 1958.

The Tricomi equation is solved by separation of variables which are certain stipulated functions of the Cartesian velocity perturbations. The symmetric flow patterns obtained from this solution are those about two-dimensional half-bodies whose ordinates vary as x^n, where $0.4 \leq n < 1$, and x is the distance along the plane of symmetry. The surface pressures on such bodies are deduced. The body whose ordinates vary as $x^{0.4}$ has a sonic surface velocity except for a leading-edge drag force at the nose. Considering a family of airfoil sections having a flat base, this particular bluff-nosed section has the least drag of those considered, and only about half that of a wedge with the same chord and base.

F. W. Diederich, USA

865. Grigoryan, S. S., On a problem in the theory of finite-span wings (in Russian), *Dokladi Akad. Nauk SSSR (N. S.)* **110,** 3, 348–350, Sept. 1956.

Linearized theory for wings with subsonic leading edges and supersonic flow.

F. W. Diederich, USA

866. Drougge, G., Some measurements on bodies of revolution at transonic speeds (in English), 9th Congres Intern. Mécan. Appl., Univ. Bruxelles, 1957; **2,** 70–77.

An experiment has been devised to test the validity of the transonic "equivalence rule" and "area rule." The pressure drags on two bodies of revolution are measured as the lateral separation between them varies from zero to 1½ body lengths. The drags are compared to that of an "equivalent" body of revolution leaving a radius $\sqrt{2}$ times the radius of the more slender bodies. The transonic area rule concept applies quite satisfactorily in this case for Mach numbers between 0.95 and 1.05.

L. H. Schindel, USA

867. Manwell, A. R., On the breakdown of plane transonic flow, *Proc. Roy. Soc. Lond.* (*A*) **245,** 1243, 481–520, July 1958.

The breakdown of mixed subsonic-supersonic potential flow is caused by the fact that the boundary-value problem is not properly set, i.e. that data are given which cannot be reconciled with each other. Author tries to show that even for a problem which is properly set the flow must break down because of infinite accelerations. These will occur at a point where the sonic line intersects the contour. After a linearization of the flow field for the vicinity of a known solution, which leads to Tricomi's equation but to different boundary conditions, author investigates the local behavior of the solutions in the vicinity of the aforementioned "critical" point, with a method similar to AMR **2** (1950), Rev. 1161. In a second part the existence of the solution of the boundary-value problem is studied.

Reviewer disagrees with author regarding his physical interpretation. Infinite acceleration does not mean breakdown of potential flow. Furthermore, reviewer believes that singular solutions studied by the author will deform the supersonic part of the contour in the vicinity of the "critical" point. Then the infinite acceleration would be caused by the singularity of the contour.

Paper displays great mathematical skill; thus, even though the aerodynamic conclusions are questionable, the contribution to the theory of Tricomi's equation is of definite value.

K. G. Guderley, USA

868. Vincenti, W. G., Wagoner, Cleo B., and Fisher, N. H., Jr., The flow over a flat plate at angle of attack at free-stream Mach number 1 (in English), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **2,** 5–14.

The results are given for calculations of the flow over the bottom (subsonic) surface of a flat plate at 13° angle of attack. The pressures and other flow characteristics are determined from numerical solution of the exact nonviscous equation. Approximate calculations by Guderley are, for the most part, in good agreement with the present solution. This work has been presented in greater detail in *NACA TN* 3723 by the same authors.

L. H. Schindel, USA

869. Graham, E. W., Notes on the use of artificial distributions of singularities in supersonic minimum drag problems, *Douglas Aircr. Co. Rep.* SM-23022, 19 pp., Dec. 1957.

A very instructive exposition of an approach to solve minimum wave drag problems subject to additional conditions. The fundamental results due to R. T. Jones in this domain are used, and it is shown, in the case of two particularly simple examples, how the application of the author's conception of "artificial" singularities leads almost immediately to results bearing on the value of minimum drag. The temporarily lost knowledge of the geometrical characteristics of the body (thickness distribution, local twist and camber distribution) can then be supplied by methods due to E. W. Graham (Douglas Co. SM-23020/1), P. Germain (*Rech. Aero.* no. 60), and B. J. Beane (Douglas Co. SM-23917), or, and this is the case of the two examples treated, more simply by slender-body-theory conceptions.

A. von Baranoff, France

870. Rowe, P. N., The thrust of a supersonic conical nozzle with non-isentropic flow, Instn. Mech. Engrs., Prepr., 7 pp., 1958.

This analysis derives an expression for the thrust of a nonideal supersonic conical nozzle in terms of coefficients that can be measured experimentally. The coefficients chosen are discharge coefficient, pressure coefficient, and the geometric divergence coefficient.

Expressions are developed for the gas velocity, the area ratio and the thrust in terms of the pressure ratio, the specific heat ratio, and the above coefficients.

Optimum operating conditions are deduced and it is shown that this modification to the usual isentropic method of design can lead to a gain in thrust of the order of 1%. This arises from choosing a larger area ratio to expand the gas properly and by arranging that the exit plate pressure is such that the optimum thrust is obtained.

From author's summary

871. Spahr, J. R., Contribution of the wing panels to the forces and moments of supersonic wing-body combinations at combined angles, *NACA TN* 4146, 62 pp., Jan. 1958.

A variety of static stability problems on cruciform wing-body combinations arise as a result of the need to operate over wider ranges of angles of attack and sideslip. The report describes a systematic experimental analysis of the effects of these angles on

the contribution of each panel of wing or body to the over-all normal force, pitching and rolling moments.

M. Holt, USA

872. Brinch, P. F., Blunt body separation at supersonic speeds, *J. Aero. Sci.* **25,** 5, 336–337 (Readers' Forum), May 1958.

873. Bolotina, K. S., Computing flow through Laval nozzles, taking into account viscosity, heat transfer and the transition into supersonic speed (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 5, 3–11, May 1956.

Author calculates approximately the viscous compressible flow through an axisymmetric Laval nozzle. By using integral expressions across the section the problem is transformed into a one-dimensional one. The equations are integrated numerically and the distribution of velocity, temperature and pressure along the axis is investigated. The velocity and temperature gradient, too, are calculated for the critical cross section. The numerical results are compared with experiments of O. A. Saunders and P. H. Calder. A satisfactory concordance is found, whereas the usual adiabatic formula gives an error of about 10%.

W. Wuest, Germany

874. Chernyi, G. G., Gas flow past bodies at high supersonic speed (in Russian), *Dokladi Akad. Nauk SSSR (N. S.)* **107,** 2, 221–224, Mar. 1956.

Czernyi considers the flow of a gas at a high supersonic velocity without using the potential and stream function equations in their classical forms. The starting point is the Euler equations of motion in a curvilinear coordinate system. Czernyi expands all the dependent functions and the vertical coordinate y in power series of $\epsilon = (\gamma - 1)(\gamma + 1)^{-1}$ and calculates the zero and the first approximations. The numerical example refers to the calculation of the pressure coefficient on a ducted body of revolution.

M. Z. v. Krzywoblocki, USA

875. Phythian, J. E., and Dommett, R. L., Semi-empirical methods of estimating forces on bodies at supersonic speeds, *J. Roy. Aero. Soc.* **62,** 571, 520–524, July 1958.

Semi-empirical methods are described for obtaining the normal forces and center of pressure positions of isolated cone-cylinders and ogive cylinders with and without boattails at supersonic speeds. The data for normal force slope and center of pressure at zero incidence is, in general, accurate to better than 10% and half caliber, respectively. The data for high incidence must be considered speculative, although reasonable agreement has been found with the very limited experimental data available.

From authors' summary

876. Wood, W. W., and Parker, F. R., Structure of a centered rarefaction wave in a relaxing gas, *Phys. Fluids* **1,** 3, 230–241, May-June 1958.

A semi-infinite gas sample bounded on the left by a piston which is stationary for time $t < 0$ is considered. It is assumed that gas molecules are subject to relaxation phenomena; otherwise the gas is ideal. At $t = 0$ the piston is withdrawn from the gas to the left at constant velocity. A set of nonlinear, hyperbolic, partial differential equations describing the state of the gas at later times $t > 0$ is derived. For purposes of further discussion in obtaining solution, a transformation of differential equations to their characteristic form is effected. Finally, variables of the problem are put into dimensionless form.

Analytical solutions of problem for very small and very large time intervals are obtained. Numerical methods based on net of characteristic curves are resorted to to obtain solution for intermediate intervals and to corroborate results in previous cases. It is shown that results of analysis for relaxing gas can be put in terms of an ordinary nonrelaxing gas if the notion of a "frozen" sound speed is introduced. This term denotes the speed of propagation into a quiescent medium of disturbances involving discontinuities in derivatives of flow variables. This conclusion holds no matter how small the relaxation times involved in the process, providing they are nonzero. It is shown that for very small times the flow is that calculated for a nonrelaxing gas with use of "frozen" sound speed. Limiting flow for very long times turns out to be that calculated by ignoring relaxation processes. It is shown further that attenuation takes place for the case of relaxing gas which brings it eventually to the flow pattern of a nonrelaxing gas. Analytical results are checked in the case of relaxing CO_2.

B. Zarwyn, USA

877. Hill, F. K., Hypersonic research (in English), 9th Congres Inter. Mecan. Appl., Univ. Bruxelles, 1957; **2,** 293–301.

A brief description of hypersonic research at John Hopkins University. Experimental equipment is discussed in the first part. Investigations directed toward producing uniform irrotational flow at $M = 10$ showed that carefully contouring two-dimensional nozzles along the usual supersonic calculation methods was not successful, due to high-temperature distortion of nozzle geometry and excessive boundary-layer growth. Conical nozzles were introduced with circular throat acting essentially as a source. A major practical difficulty lies in the high supply temperatures (about 4500 K for $M = 10$) required to produce flow conditions similar to free flight, whereas conventional means for supplying high-pressure high-temperature gas are limited to about 1000 K. Shock tubes and high velocity guns may be suitable solutions for studying phenomena which do not require flow duration greater than the millisecond order. There is definite need for wind-tunnel operation time of 10–20 sec.

Using high stagnation temperatures will result in molecular dissociation and perhaps in some ionization, so that expansion rate should be adjusted according to relaxation time if a fairly normal gas is to be expected in the test section. Other means to accelerate thermodynamic equilibrium are (a) increasing gas pressure or density and (b) adding a light impurity to the gas such as hydrogen or helium, such molecules producing collisions much more effective in reducing relaxation time than those of the working fluid (N_2 or air). Also the heat-transfer problem must be solved if high velocity streams of sufficient flow duration are to be performed.

Second part describes some results of boundary-layer measurements made on the nozzle walls near exit, where curvature effect was computed for comparison with flat plate or two-dimensional data. Typical velocity profiles for $M = 9$ and $M = 10$ are quite different from lower Mach number profiles. Laminar region is relatively thick and turbulent portion follows a $\frac{1}{5}$ power velocity index. For $M = 9$ a fully developed turbulent layer was observed with a transition $Re = 4$ million and a quite stable laminar sublayer. Further details are given in form of curve plots.

Increasing exit Mach number up to 15.2 was performed with helium, and similar boundary-layer surveys showed almost completely laminar velocity profiles. Due to very low densities involved, appreciable slip and viscous effects were observed on the probes, making corrections necessary. As much as 50% correction of total head reading was required in some cases.

P. Schwaar, France

878. Rose, P. H., Adams, M. C., and Probstein, R. F., Turbulent heat transfer on highly cooled blunt-nosed bodies of revolution in dissociated air, Heat Trans. and Fluid Mech. Inst., Univ. of Calif., Berkeley, Calif., June 1958, 143–155.

Turbulent heat-transfer measurements in a region of large wall cooling have been made in shock tubes under conditions simulating hypersonic flight at velocities up to 20,000 fps. The experiments covered a Reynolds number range of 10^4 to 3×10^6 and a range of

wall cooling corresponding to enthalpy ratios of 5 to 50. As much as 30% of the air was dissociated at the edge of the boundary layer in these experiments.

To correlate the experimental results, a semi-empirical theory for highly cooled turbulent boundary layers has been developed which takes into account the effects of variable fluid properties in the boundary layer, the pressure gradient, axial symmetry and transport by diffusion of atoms. A correlation of the experimental data with the proposed semi-empirical theory is made.

From authors' summary by C. E. Carver, Jr., USA

879. Michel, R., Experimental study of the turbulent boundary layer and its interaction with the shock wave on a half-aerofoil in transonic flow (in French), *ONERA NT* 47, 22 pp., 1958.

A two-dimensional half-airfoil, of circular arc profile and total thickness-ratio 12%, was mounted on one wall of a transonic tunnel. Pressure distribution on airfoil was measured for range of stream Mach numbers from the critical to about 0.91, giving peak local Mach numbers up to about 1.4. For each condition, boundary layer over rear half of airfoil was explored by pitot tube. Boundary layer was turbulent throughout, with thickness of order 5% chord at mid-chord position. Results show that displacement thickness at 95% chord increases by relatively small amount as shock wave develops with increasing Mach number, while momentum thickness at this position is almost constant. Calculations of growth of momentum and displacement thicknesses over rear part of airfoil by various methods lead to values considerably less than those found from pitot traverses. Discrepancies are apparently *not* caused by shock wave, since growth of boundary layer is predicted correctly as far as a point downstream of shock wave. Discrepancies become serious as separation is approached; reviewer remarks that all the calculations are based on von Karman momentum equation, known to be unreliable for turbulent boundary layer approaching separation, unless additional terms are introduced.

W. A. Mair, England

880. Kinzo, H., Asymptotic behaviour of a detached shock wave in a nearly sonic flow (in English), 9th Congrès Intern. Mecan. Appl., Univ. Bruxelles, 1957; **2**, 40–49.

The shape and location of a detached shock wave is determined for the case of $M \sim 1$. For Mach number only slightly greater than 1, the shock moves far upstream of the body, hence the detailed shape of the body has little effect on the shock wave. This fact is used to obtain solutions for the shock position and radius of curvature in the two-dimensional case. An interesting intermediate result is an adjustment of Cole's solution for high-subsonic flow to make it approach Guderley's at $M = 1$.

L. H. Schindel, USA

881. Campbell, R. G., Initial wave phenomena in a weak spherical blast, *J. Appl. Phys.* **29**, 1, 55–60, Jan. 1958.

The initial waves created by the sudden release of a spherical volume of compressed air in a limitless environment of air at constant state are predicted analytically using an iterative method of solution by characteristics for the case of a specific weak blast. Pressure-time records have been obtained within the compressed air and in the immediate environment of the spherical blast during its early stages, using a pyramidal shock tube. The experimental results corroborate the existence and position in time and space of the inner and reflected shock waves predicted analytically. The present results for a weak spherical blast are in substantial agreement with the analytical and experimental results obtained previously by other investigators for a considerably more powerful blast. The shock tube, in pyramidal or conical form, appears to offer considerable promise for further research on spherical blast phenomena.

From author's summary by C. C. Taylor, USA

882. Chernyi, G. G., Unidimensional unsteady flow of a perfect gas with strong shock waves (in Russian), *Dokladf Akad. Nauk SSSR (N. S.)* **107**, 5, 657–660, Apr. 1956.

A theoretical treatment in plane, axial or spherical symmetry where a piston drives a strong shock into gas at rest. The specific volume is instantaneously reduced by the factor $\epsilon = (\gamma - 1)/(\gamma + 1)$, γ being specific heat ratio.

The radius, pressure and density profiles behind the shock are written as power series in ϵ, the coefficients being functions of Lagrangian radius and time. Equations of motion are then solved to give successive coefficients, all in terms of the motion history of the piston.

As an example, similarity solutions with $\gamma = 1.4$ are studied and exact numerical solutions compared with the zero and first-order solutions. The latter give very good agreement for the ratio *(piston pressure)/(shock pressure)* in all cases studied—even for "strong explosion" theory, which departs most from the "thin-shocked-layer" concept underlying the method. It is pointed out that results of this method for the density profile would not be valid in the explosion case.

Reviewer found paper brief, clear and interesting.

A. H. Armstrong, England

883. D'iakov, S. P., The interaction of shock waves with small perturbations, I, II (in Russian), *Soviet Phys.-Tech. Phys.* **6**, 4, 729–747, Apr. 1958. [Translated from *Zh. Tekh. Fiz., Akad. Nauk SSSR* **33**, 948–974, Apr. 1958 by Amer. Inst. Phys., Inc., New York, N. Y.]

In part I the interaction of stationary, two-dimensional, oblique shock waves of arbitrary intensity with small perturbations is considered in the linear approximation. The flow behind the shock wave is assumed to be supersonic. The results are applied to the study of the interaction with weak discontinuities, weak shock waves, and with the interface between two media of slightly different acoustical properties.

In part II consideration is given to the general case of the interaction of small perturbations with a two-dimensional shock wave of arbitrary intensity in the case of subsonic flow behind the shock. A solution is given for the interaction of weak and weak-tangential discontinuities with the shock wave. In both cases, the weak-tangential discontinuity formed behind the shock wave possesses a specific logarithmic discontinuity.

From the author's summary by H. A. Stine, USA

884. Brun, E. A., and Devienne, F. M., Experimental study of stagnation temperature in free molecular flow (in French), 9th Congrès Intern. Mecan. Appl., Univ. Bruxelles, 1957; **2**, 274–284.

Free molecular flow régime prevails when the mean free path is great as compared to the dimensions of the body immerged. However, the number of molecules in a macroscopically small volume is still large enough to permit the definition of gas pressure, temperature, etc., even at very low densities.

Paper presents some results obtained at Knudsen numbers greater than 5 on small square plates of 6 × 6 mm and 0.1-mm thickness subjected to perpendicular molecular flow. Experimental apparatus consists of a rotating arm carrying the plates symmetrically on both ends at a diameter of 1.25 m by means of Plexiglas struts and placed in an evacuated receiver. Results may be summarized as follows:

Stagnation temperature increases are proportional to the square of the velocity and to a 0.77 power index of the pressure, approximately. They further depend upon the gas nature: a greater molecular mass corresponds to a greater stagnation temperature increase. Plate material and surface condition have a definite influence. As an example, a blackened plate shows a stagnation temperature increase which amounts only to the $^3/_5$ fraction of that observed on a nickel-plated one.

Results are in good agreement with theory provided that accommodation factor is allowed to vary not only with gas nature and body properties, but also with gas velocity and pressure.

P. Schwaar, France

885. Lunc, M., and Lubonski, J., Approximative solution of a problem in rarefied gas flow around a body (in French), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **2,** 285–292.

According to authors, solution applies for monatomic gas in the domain between free molecular and slip flow régime. Method consists of computing impact effect on the body of molecules having undergone no encounter with another one, then of molecules having undergone one encounter, further two encounters, etc. Present approximation is limited to computation of aerodynamic force contribution of first- and second-class molecules. As a numerical example, drag coefficient of an infinite plane strip perpendicular to flow velocity is calculated and plotted in function of $\alpha = A/L$ (A = half strip width, L a parameter similar to molecular mean free path).

Too concise mathematical development and a very deficient printing make paper really unintelligible for the practical engineer.

P. Schwaar, France

886. Vereshchagin, L. F., Semerchan, A. A., Firsov, A. I., Galakmionov, B. A., and Filler, F. M., Study of the hydrodynamics of fluid jets ejected from the nozzle under a pressure up to 1500 atm (in Russian), *Zh. Tekh. Fiz.* **26,** 11, 2570–2577, Nov. 1956.

Boundary Layer

(See also Revs. 872, 879, 899, 908, 962, 973, 1034, 1035, 1087)

887. Bourne, D. E., and Davies, D. R., On the calculation of eddy viscosity and of heat transfer in a turbulent boundary layer on a flat surface, *Quart. J. Mech. Appl. Math.* **11,** 2, 223–234, May 1958.

In previous paper [AMR **10** (1957), Rev. 3075] authors presented method for calculating distribution of rate of heat transfer for incompressible, turbulent flow over a heated flat plate when the plate temperature is independent of downstream distance. For this calculation it is necessary that the measured velocity profile and measured distribution of eddy viscosity be available. Further, it is assumed that: (a) Reynolds' analogy is valid, (b) a particular similarity law exists for the velocity profile, and (c) a set of empirical formulas for distribution of mean velocity, and hence corresponding distribution of temperature, is valid. In present paper, authors have extended previous work so that while again heat-transfer rates are predicted, the need for measured velocity profile and measured eddy viscosity distribution is eliminated. Use of an empirical formula for the surface shearing stress in terms of the main stream velocity coupled with a logarithmic formula for the mean velocity provides a similarity velocity distribution which agrees well, over the inner 30% of the boundary layer, with measurements made by Elias [ZAMM **10,** p. 1, 1930]. This similarity profile is then used in the integration of the equation of motion, and the distribution of eddy viscosity can be calculated numerically.

Simplification to this calculation is noted for cases where a power law can be used to represent with reasonable accuracy the similarity profile. Computed rates of heat transfer are in reasonable agreement with measurements of Elias. Method is applicable only when main stream velocity is large enough so that virtual origin of the turbulent layer can be taken at the leading edge of the plate.

A. Ritter, USA

888. Coles, D., Remarks on the equilibrium turbulent boundary layer, *J. Aero. Sci.* **24,** 7, 495–506, July 1957.

The equilibrium turbulent boundary layer is defined by the fact that a certain shape parameter of the mean-velocity profile is constant in flow direction. The pressure distribution corresponding to such a given equilibrium flow, for which the velocity profile is constant by use of the law of the wall and the momentum defect law, can be computed by assuming that a certain parameter $D = (\tau_w/q)dq/d\tau_w$ is constant, where q and τ_w are the dynamic pressure in the free stream and the shearing stress at the wall, respectively. The hypothesis D = constant is suggested by a study of the integrated continuity equation and is supported by a rigorous analogy between the class of equilibrium flows defined by Clauser and the class of laminar flows studied by Falkner and Skan. The hypothesis D = constant is also verified using experimental data for several equilibrium turbulent flows and is interpreted physically from a kinematic point of view.

Reviewer remarks that, in contrast to the Falkner and Skan solution for laminar boundary layers, there is no complete similarity for the equilibrium turbulent boundary layer on a smooth wall. As a consequence, several characteristics, which are constant in the laminar case, vary slightly in the turbulent case. The hypothesis D = constant is substituted for the supposition made by other authors [Townsend, AMR **9,** (1956), Rev. 4000; Reviewer, AMR **3,** (1950), Rev. 2729] that similarity exist also for the shear stress distribution. Which of these conditions is better satisfied in an actual equilibrium flow cannot be decided at the present time.

J. C. Rotta, Germany

889. Baxter, D. C., and Flugge-Lotz, Irmgard, The solution of compressible laminar boundary-layer problems by a finite difference method, Part II. Further discussion of the method and computation of examples, Stanford Univ., Div. Engng. Mech., Tech. Rep. 110 (ASTIA AD 148 040), 220 pp., Oct. 1957.

This paper treats a fluid with arbitrary physical properties, but does not consider the effect of chemical reactions or diffusion. The numerical examples are confined to $\gamma = 1.4$ and $Pr = 0.72$.

Finite difference approximations are applied to the Crocco form of the boundary-layer equations. Special procedures are given for dealing with the values at the wall and "overshoot" profiles. The adequacy of the methods for dealing with overshoot are unsettled and it may be more convenient to handle such problems in the physical plane. The singularity at the leading edge, or stagnation point, is avoided by starting the solution some distance downstream. A number of suitable initial profiles are tabulated. The calculations are extremely laborious because the procedure is only stable for small streamwise steps. It is estimated that to proceed a distance equal to the distance of the starting point from the leading edge takes from 10 to 400 hours on an IBM 650.

The present paper calculates a large number of examples a relatively short downstream distance, so the singularity at the separation point was not approached. Comparison of the numerical results with various analytical approximations showed that when the surface temperature varied rapidly in the streamwise direction, integral methods which assumed equal thickness for the velocity and temperature profiles gave erroneous results as did "correlation" methods which ignore boundary-layer history. On the other hand, Lighthill's method gave good agreement. There was an unexplained discrepancy with integral methods which assume different velocity and temperature thickness.

While this voluminous report will be extremely useful to workers in the field, much remains to be done. For example, reviewer would be interested in a study of the effect of a small variation in the initial profile when the calculation proceeds a large distance downstream.

W. Squire, USA

890. Flugge-Lotz, Irmgard, and Howe, J. T., The solution of compressible laminar boundary layer problems by a finite differ-

ence method, Part III. The influence of suction or blowing at the wall, Stanford Univ., Div. Engng. Mech., Tech. Rep. 111 (ASTIA AD 148 041), 44 pp., Oct. 1957.

The calculation of the effect of suction or blowing on a laminar boundary layer is of increasing interest in connection with various attempts to apply boundary-layer control to aircraft.

The previous work of the authors (see preceding review) is modified to take a normal velocity component at the wall into account. Numerous examples, including subsonic and supersonic flows over hot and cold walls with and without pressure gradient, are worked out.

It is found that for flow with a pressure gradient it is easier to specify the shear at the wall and compute the required normal velocity. This type of problem is said to be of more direct interest to designers. W. Squire, USA

891. Krzywoblocki, M. Z. v., On the boundary layer in a corner by use of the relaxation method, *Ganita* **7,** 2, 77–112, Dec. 1956.

Equations of motion in the boundary layer along the corner are written using known Prandtl variables, and taking into account only coefficients of lowest power of $\xi = (\nu_\infty/Vx)^{1/2}$. Pressure is considered constant in every direction normal to the edge.

Relaxation method is applied for both incompressible and compressible cases, using a restricted number of points. Every step is described in detail. Calculated curves of velocity and temperature are given. G. Moretti, USA

892. Patraulea, N. N., Theory of near-rectilinear wakes and its application to the hypersustentation of airfoils with blowing (in French), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **2,** 341–348.

Idea of permeable control surfaces and bodies is combined with an assumption that turbulent wake downstream of those permeable bodies extends in almost straight lines. The field of velocity perturbation with respect to that at infinity can be determined by Biot-Savart formulas. Outside of the wake a velocity potential exists. But it is shown that for the wake itself a function may be found whose gradient expresses velocity of perturbation. This approach is applied then to analysis of airfoils with blowing at the flap leading edge. Examples of flow visualization around such airfoils are shown, but to this reviewer it is not clear to what extent they support the theory. W. Z. Stepniewski, USA

893. Dhawan, S., and Narasimha, R., Some properties of boundary layer flow during the transition from laminar to turbulent motion, *J. Fluid Mech.* **3,** 4, 418–436, Jan. 1958.

Transition in the boundary layer on a flat plate is examined from the point of view of intermittent production of turbulent spots. On the hypothesis of localized laminar breakdown, for which there is some experimental evidence, Emmons' probability calculations can be extended to explain the observed statistical similarity of transition regions. Application of these ideas allows detailed calculations of the boundary-layer parameters, including mean velocity profiles and skin friction during transition. The mean velocity profiles belong to a universal one-parameter family with the intermittency factor as the parameter. From an examination of experimental data the probable existence of a relation between the transition Reynolds number and the rate of production of the turbulent spots is deduced. A simple new technique for the measurement of the intermittency factor by a Pitot tube is reported.

From authors' summary by M. H. Bertram, USA

894. Petersohn, E. G. M., The pressure drag due to turbulent separation on bodies of revolution with varying boundary-layer thickness (in English), *Flygtekn. Försöksanst. Medd. Rep.* 75, 7 pp. + 3 tables, 1957.

The effect of the boundary-layer thickness on the flow separation over the rear portion of bodies of revolution has been investigated by pressure measurements. For slender bodies there seems to exist a tendency for the pressure drag to decrease with decreasing boundary-layer thickness. For less slender tails with strong separation, the latter tendency can hardly be traced.

The results are used to estimate the drag due to separation at high Reynolds numbers. From author's summary

895. Struminskii, V. V., A three-dimensional boundary layer on an arbitrary surface (in Russian), *Doklady Akad. Nauk SSSR (N. S.)* **108,** 4, 595–598, June 1956.

Author derives equations of a three-dimensional boundary layer of an incompressible fluid on an arbitrary surface. Introducing a curvilinear orthogonal system of coordinates, connected with the surface in question, he gives the three-dimensional boundary-layer equations in a form from which the influence of the main radius of curvature can well be seen. Author deduces that his equations are a limit form of the Navier-Stokes equations for an unbounded growth of Reynolds number. J. Polasek, Czechoslovakia

896. Tarassyuk, V. A., The influence of the Mach number on the magnitude of rarefaction at the wall (in Russian), *Trudi Leningr. politekhn. in-ta* no. 176, 154–159, 1955; *Ref. Zh. Mekh.* no. 3, 1957, Rev. 3146.

The problem is solved of the interaction between an external flow and a boundary layer, with the allied problem of the determination of the amount of rarefaction at the bottom. The author puts the equations of mixing as

$$\frac{dm}{dx} = k\rho_0 u \qquad \left(m = \int_0^\delta \rho u_x dy\right)$$

where ρ_0, u are density and velocity at the outer limit of the boundary layer; k coefficient of mixing; k and $(1 - \delta^*/\delta)$ are functions of the Mach number M.

$$k = \frac{0.0955}{1 + \dfrac{\gamma - 1}{2} M_0^2}; \qquad \left(1 - \frac{\delta^*}{\delta}\right)_c = \frac{0.45}{1 - 0.67\,\dfrac{\gamma - 1}{2} M_0^2}$$

where M_0 = Mach number of external flow.

In the selection of the constants it has been assumed that $\delta^*/\delta\delta^{**}/\delta$, determined in Dorodnitsin variables, have the same values as for a free, turbulent jet. Solving the problem in the manner of Crocco and Lees [*J. Aero. Sci.* **19,** no. 10, 1952] author obtains for the rarefaction at the wall, results agreeing well with the experimental figures. I. P. Ginzburg

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Turbulence

(See also Revs. 961, 970, 1060, 1094)

897. Mills, R. R., Jr., and Corrsin, S., Effect of a contraction on turbulence and temperature fluctuations, Heat Trans. and Fluid Mech. Inst., Univ. of Calif., Berkeley, Calif., June 1958, 15–24.

Approximately homogeneous and isotropic fields of turbulence and temperature fluctuations generated by a warm grid have been sent through a contraction. In addition to confirming the well-known turbulence anisotropy induced by homogeneous strain, measurements show effects of skewness of both longitudinal velocity fluctuation and its derivative. The concomitant anisotropy in temperature field accelerates the decay of temperature fluctuations.

From authors' summary by C. E. Carver, Jr., USA

898. Cometta, C., An investigation of the unsteady flow pattern in the wake of cylinders and spheres using a hot-wire probe, AFOSR TN 57-760 (Brown Univ., Div. of Engng., TN WT-21; ASTIA AD 136 749), 19 pp. + 12 figs., Oct. 1957.

Results obtained by hot-wire anemometer surveys of wakes behind circular cylinders at subsonic speeds and high Reynolds numbers are presented. The investigation was concerned in particular with the behavior of the Strouhal number at and near the critical Reynolds number.

The irregular range above a Reynolds number of 300, in which turbulent velocity fluctuations accompany the periodic formation of vortices, and which was believed not to extend beyond Re = 10,000, is shown to exist up to Re = 1,000,000.

Above a Reynolds number of Re = 200,000 and a cylinder diameter to channel width ratio of 0.23 there appeared two simultaneous vortex streets. On the outside of the ordinary vortex street there were observed two layers containing oscillations of lower frequency.

The dependence of the Strouhal number on Reynolds number behind three-dimensional bodies, such as spheres, was determined. Periodic formation of vortices could not be observed above a Reynolds number of 40,000.

For spheres of diameter greater than about 2 cm there appeared to be a critical Reynolds number of 7400 at which the Strouhal number changed rapidly from one value to a very much different value. This phenomenon could not be satisfactorily explained.

It is believed that there exists only one type of vortex formation for spheres, namely a relatively stable arrangement of vortex loops. From author's summary

899. Grant, H. L., The large eddies of turbulent motion, *J. Fluid Mech.* **4,** 2, 149-190, June 1958.

Paper describes an experimental investigation of the form of the large-scale motions in turbulent flow. These motions have been found to be more ordered than has usually been supposed and their origin and dynamics are discussed in terms of physical models of typical eddies.

Nine components of the double velocity correlation tensor were measured at a number of positions in the wake of a circular cylinder and in a "flat plate" boundary layer. These were supplemented by measurements of correlations with separations in directions other than the axial ones. In the wake, the correlations at large values of the separation are explained in terms of two types of large-scale motion. One of these is a pair of vortices, side by side and rotating in opposite directions with axes aligned approximately normal to the plane of the wake. The other typical motion is a series of jets in which turbulent fluid is projected outward from the core of the wake. It is suggested that these are the result of an instability of the turbulent shear stress. A qualitative explanation of the apparent structural equilibrium of the wake is given in terms of this instability. The vortex pair eddies were not found in the boundary layer, but there is evidence of jets much like those in the wake.

Correlations measured in grid turbulence have been found to be highly anisotropic and consistent with the presence of vortex pair eddies. When a plane strain was applied to grid turbulence, the effect on the correlations suggested the presence of a stress instability similar to that postulated for the wake.

From author's summary by L. M. Grossman, USA

900. Walter, T. S., Diffusion from an infinite line source lying perpendicular to the mean wind velocity of a turbulent flow, *Quart. J. Mech. Appl. Math.* **10,** 2, 214-219, May 1957.

Methods of Roberts and Sutton [See O. G. Sutton, "Micrometeorology," McGraw Hill, 1953] are extended to the prediction of pollutant concentration downwind of a smoke source of infinite horizontal extent but limited vertical extent. This is an idealization of the case of smoke emanating from a large number of equal-height stacks arranged in a line perpendicular to the wind.

Results are expressed as an integral involving Bessel functions; this simplifies to an exponential function identical to Roberts' solution for a source at ground level.

For the elevated source an expression is derived for the distance downstream at which a maximum pollutant concentration would be observed at the ground.

No experimental data are given and to the reviewer's knowledge none exists which would satisfactorily test the predictions. The results as presented are clumsy to manipulate and would have to be reduced to graphical or tabular form for convenient use.

F. I. Badgley, USA

901. Dou Go Zhen′, Turbulent motion in a cylindrical pipe (in Russian), *Sb. nauch. rabot. Stud. nauch. o-vo, Leningr. in-ta inzh. vod. transp.* no. 1, 28-33, 1956; *Ref. Zh. Mekh.* no. 4, 1957, Rev. 4232.

Author studies the problem of the distribution of velocities in turbulent uniform steady motion in pipes, starting from concepts explained in another of his papers [title source, no. 1, p. 5, 1956]. A formula is suggested for the velocity profile:

$$\frac{u}{u_0} = 1 - \frac{r^2}{2lr_0 + r_0^2}$$

where r_0 is the radius of the pipe, l a parameter dependent on the roughness of the walls of the pipe, and u_0 the velocity on the axis of the pipe, i.e. at $r = 0$.

This formula is compared with the test data of F. A. Shevelev on the distribution of velocities in new steel and cast-iron tubes, while a satisfactory agreement between test and theory is established. It should, however, be noticed that the influence of the Reynolds number on the velocity distribution, which is very marked for new steel and cast-iron pipes, is not reflected in author's formula. A. D. Al′tshul′

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Translation, courtesy Ministry of Supply, England

Aerodynamics

(See also Revs. 846, 851, 852, 861, 864, 865, 868, 869, 892, 929, 930, 931, 932, 934, 935, 936, 939, 1029, 1041)

Book—902. Riegels, F. W., Airfoils—wind tunnel data, theory [Aerodynamische profile—Windkanalmessergebnisse, theoretische Unterlagen], Munchen, R. Oldenbourg, 1958, 278 pp.

Book represents first major compilation of airfoil data in the German language since 1932. In addition to the wealth of German material an excellent selection of U. S. and British airfoil data is included. It constitutes a fine addition to the literature on wing sections and supplements the corresponding U. S. text [Abbott, I. H., and von Doenhoff, A. E., "Theory of wing sections," N. Y., McGraw-Hill, 1949] which, to reviewer's knowledge, is now out-of-print.

Organization and content of Riegels' book is as follows: An introductory chapter on definitions and survey of airfoils is followed by a detailed discussion on wind tunnels used in airfoil testing, their turbulence levels, and the techniques of testing and of data corrections. Chapter 3 deals with force and moment coefficients in incompressible and subsonic compressible flow, while effects of surface roughness, waviness, and cavitation phenomena in fluids are taken up in chap. 4. The next two chapters cover high lift devices and the effects of boundary-layer control, respectively.

The theory of wing sections is contained in the next four chapters as follows. Chapter 7 gives the relation of airfoil shape to pressure (velocity) distribution for inviscid incompressible flow. Chapter 8 outlines the procedures for calculating the pressure distribution for a given airfoil shape, and for obtaining the airfoil shape from a given velocity variation. An outline of the exact methods of conformal mapping is also included in this chapter. The role of viscosity is discussed in chap. 9 which contains the effects of friction on pressure distribution and lift, boundary-layer thickness calculations and stability theories, determination of profile-drag and lift-drag polars. Airfoils in compressible flow are discussed in chap. 10, including subsonic, transonic, and supersonic cases. Each chapter contains an extensive list of applicable literature.

A wealth of tabular data is collected in chap. 11, viz., geometric and aerodynamic data for 459 airfoils, ordinates and velocity distributions for 20 mean lines, ordinates for 216 airfoils, ordinates and velocities for 16 NACA sections, experimental coefficients (c_l, c_d, c_m) versus angle of attack for 106 airfoils, geometric and aerodynamic data on 66 high lift devices, and three tabulations of coefficients needed in theoretical calculations.

Chapter 12 contains pictorial presentations of pressure distributions for some 50 airfoils and lift-drag and moment coefficients of some 112 airfoils.

Reviewer considers book an up-to-date and complete summary of theory and experiments of airfoils. The usefulness might be further enhanced by adding a list of symbols used throughout.

H. P. Liepman, USA

903. Truckenbrodt, E., and Gersten, K., Experimental and theoretical investigation of delta wing fuselage arrangement in symmetrical flow (in German), *Z. Flugwiss.* **5**, 7, 204–216, July 1957.

The results are given of three component measurements on delta-wing fuselage combinations with large variations in fuselage length for two fuselage shapes. The shift of the aerodynamic center of the measured arrangements relative to that of the wing alone is calculated in the theoretical part of the report. The effect of aspect ratio and also that of the ratio of fuselage width to wing span is investigated. From authors' summary

904. McLellan, C. H., Bertram, M. H., and Moore, J. A., An investigation of four wings of square planform at a Mach number of 6.9 in the Langley 11-inch hypersonic tunnel, *NACA Rep.* 1310, 18 pp., 1957.

The results of tests of four wings at a Mach number of about 6.86 and a Reynolds number of 0.98×10^6 are presented. The wings had square planforms with 5-percent-thick diamond, half-diamond, wedge, and half-circular-arc sections. The boundary layer was found to have a large effect on the pressure distributions. Reasonable agreement was indicated between the aerodynamic coefficients from experimental pressure data and inviscid theory. Total-drag measurements showed good agreement with the theory at low angles of attack when the effects of surface friction were included. At the higher angles of attack, both lift coefficient and drag coefficient were slightly below the values predicted by the two-dimensional theory. From authors' summary

905. Newby, K. W., The effects of taper on the super-velocities on three-dimensional wings at zero incidence, *Aero. Res. Counc. Lond. Rep. Mem.* 3032, 48 pp. + 1 table + 49 figs., 1957.

Relationships have been derived for expressing the velocities on three-dimensional tapered wings at zero incidence in terms of the velocities on untapered infinite swept wings. The theoretical investigation of the effects of taper is confined to simple wings having airfoil sections formed by cubic or parabolic arcs; some experimental evidence is given to show that the results of this investigation can probably be applied quantitatively to wings having conventional airfoil sections.

The results given in this report show that planform and thickness taper have a marked effect on the velocities near the center of a wing, but that these effects decrease with increase of sweepback.

A calculation method is outlined for applying the results obtained for wings having parabolic-arc airfoil sections to wings having arbitrary section shapes.

From author's summary

906. Chawla, J. P., A vectorial representation of aerodynamic forces acting on a thin rectangular wing oscillating harmonically in supersonic potential flow, *J. Aero. Sci.* **25**, 5, 329–330, May 1958.

A method of representing aerodynamic lift and moment acting on a thin rectangular wing oscillating harmonically in supersonic potential flow is indicated. This may help the practicing flutter engineer gain a better understanding of the nature of aerodynamic forces exciting the structure. This representation should also prove useful for (a) solution of flutter determinant by vector methods, (b) flutter studies by analog methods, (c) correlation with lift and moment of oscillating airfoils measured in a wind tunnel, (d) dynamic testing of structures, and (e) flight testing for flutter.

From author's summary

907. Hurley, D. G., Wallis, R. A., and Calame, Mary, Experiments on the effects of air jets and surface roughness on the stalling characteristics of a 5 foot chord NACA 64A006 aerofoil, *Aero. Res. Lab., Melbourne, Austral., Rep.* A 107, 22 pp. + 2 tables + 23 figs., Dec. 1957.

Experiments carried out on a five-foot chord two-dimensional model of the NACA 64A006 airfoil in the 9-ft × 7-ft wind tunnel have shown that spanwise rows of air jets or suitably controlled roughness located near the leading edge lead to appreciable increases in the nose stalling incidence of the airfoil with resulting improvements in its lift, drag and pitching moment characteristics. Air jets or roughness used on the lower surface reduced the laminar separation bubble to minute proportions, and air jets on the upper surface led to a small delay in turbulent separation. The test Reynolds number range was 1.28×10^6 to 6.4×10^6.

From authors' summary

908. Poisson-Quinton, Ph., and Jousserandot, P., Effect of tail bleed on the aerodynamic characteristics of a wing at high speeds (in French), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **2**, 527–550.

Authors present wind-tunnel results of tests on a lenticular airfoil at $0.6 < M < 2.5$. The effect of bleed-air ejection near the airfoil tail on the two-dimensional characteristics has been studied, to consider possible replacement or improvement of the more conventional control devices. This experimental study is welcomed, but it suggests no new aspects.

K. J. Yap, Holland

909. Wood, A. D., and Gould, D. G., The effect of icing on aircraft equipped with vortex generators, *Nat. Aero. Establ. Canad.* LR-220, 3 pp. + 1 table + 6 figs. + 1 appendix, Apr. 1958.

By reproducing in plastic the ice formation which has been found to build up on vortex generators tested under heavy icing conditions in a low-temperature wind tunnel, it has been possible to carry out flight tests to determine the effects of such icing on vortex generator installations on a Harvard and a CF-100 aircraft. From these tests it has been found that for an installation of delta-shaped, co-rotating vortex generators mounted well forward on the wing, icing of the generators has only a very small effect on the stalling speeds and no adverse effect on aircraft handling near the stall. Any increase in drag which occurs as a result of vortex generator icing is small, and insufficient to be a cause of concern.

From authors' summary

Vibration and Wave Motions in Fluids

(See also Revs. 705, 960, 1059)

910. Le Méhauté, B., The perviousness of rock fill breakwaters to periodic gravity waves, Part I. Study of the periodic flow laws in a permeable structure; Part II. Study of the similitude laws for permeability in a rock-filled structure; Part III. Experimental research (in French), *Houille Blanche* **12,** 6, 903–919, Dec. 1957; **13,** 2, 148–179, Mar.-Apr. 1958; **13,** 3, 255–269, May-June 1958.

Transmission of waves through a breakwater was a subject untreated until appearance of this paper. Author develops subject completely from basic principles dealing with equations of motion, similitude laws and experimental verification.

Type of flow considered is that through a porous media in which voids are comparatively large. Flow is thus turbulent in most cases. Equations of motions are linearized and thus readily integrated by neglecting an inertia term and including a mean velocity in constant of friction term. Solution is even thus too complex for ready practical application. Approximations are made for a structure which is short compared to the wave length. It is shown that the wave length of the flow within the structure is shorter than in the unrestricted flow. Structure thus imposes both a phase shift and an attenuation on the wave.

Model studies of breakwater designs must be based on the Froude criterion, hence the Reynolds criterion for similarity of friction effects cannot be satisfied. Author discusses this problem extensively from opposing standpoints of theoretical perfection and practical engineering requirements. It is shown how good similarity can be achieved using the same void ratio in the model and prototype together with a relative magnification of the stone size, the stones in the model being made of the same material but larger than the scale ratio would dictate.

To test the solution and approximations made above the author performed an extensive series of experiments in a wave flume. The main factors observed were the amplitudes of the waves refracted from the front of the breakwater and transmitted through to the pond behind. A large variation of amplitude is included. The results verify well the author's derivations and in addition demonstrate several basic facts of this flow; e.g. the transmitted wave increases in size with increasing period, the more dense the structure the larger the reflected wave. It is shown that in a typical situation only the long waves (about 30 sec) will penetrate the structure.

Reviewer believes the paper will be of interest both to practicing engineers and persons engaged in hydraulic research. The mathematical derivations are sketchy but adequate. The practical significance of the results is explained in terms useful to the designer. W. D. Baines, Canada

911. Shimoyama, Y., and Ito, T., Experiments on the surging of a blower, *Bull. JSME* **1,** 1, 57–63, Jan. 1958.

This paper deals with experiments on surging phenomena. The results may be summarized as follows:

(1) The air column in the pipeline vibrates in a certain form resembling that of free vibration.

(2) The more rapid the revolutions of a blower become, the more violent the surging grows, and the more important role the characteristic of a blower plays in determining the amplitude of the surging.

(3) When the length and area of a cross section of the pipeline are fixed, the surging is apt to be built up according to the volume of the tank.

(4) The feature of the surging is considerably influenced by the conditions under which the energy is dissipated from vibrating air column. From authors' summary

912. Rakhmanov, A. N., Two conditions of unsubmerged and submerged bottom hydraulic jump and the lengths of the eddy section of this jump (in Russian), *Izv. Vses. n.-i. in-ta gidrotekh.* **55,** 37–74, 1956; *Ref. Zh. Mekh.* no. 4, 1957, Rev. 4278.

Results are given of the experimental hydraulic investigations made by the author in the period 1948–1952. The presence in unsubmerged and submerged bottom hydraulic jumps of two basic conditions, i.e. bottom and bottom-surface, and also of intermediate conditions, which the author calls incomplete bottom and bottom-surface conditions, is noted.

Experimental investigations made it possible to determine (in the conditions in which the tests were made): the empirical relationships for determining the length of the surface eddy in the case of unsubmerged and submerged bottom hydraulic jumps of the boundary of formation of incomplete and completely developed (complete) bottom-surface conditions of the bottom jump; the extension of the bottom turbulent zone in bottom-surface conditions of the jump and test data relating to the vertical dimensions of the bottom turbulent zone of the jump.

Test data on the pulsation of the length of the surface eddy of the bottom jump and of the length of the zone of the bottom vortex of the bottom-surface jump were obtained.

A. N. Akhutin
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

913. Sekerzh-Zen'kovich, Ya. I., Theory of stationary capillary waves of finite amplitude (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **109,** 5, 913–915, Aug. 1956.

Author derives higher-order approximations for the nonlinear effects of finite amplitude coupled gravitational-capillary waves, by means of a conformal transformation. Results of physical interest are undoubtedly present, but are heavily camouflaged by symbols. Author states that his results illustrate the presence of surface mass transport. I. Tolstoy, USA

Fluid Machinery

(See also Revs. 613, 629, 690, 724, 756, 941, 942, 949, 951)

914. Kriebel, A. R., Seidel, B. S., and Schwind, R. G., Stall propagation in a cascade of airfoils, *NACA TN* 4134, 57 pp. + 3 tables + 58 figs., June 1958.

The phenomenon of rotating stall is investigated by schlieren and interferometer photography, by piezoelectric pressure pickup, by hot-wire measurements of velocity and flow direction. The experimental evidence suggests a vortex flow model where the vortex shed from a stalling or unstalling blade moves across the passage and stalls the adjacent blade. The equation derived from analysis of this model appears to predict the propagation velocities within 15%. A qualitative prediction of the analysis is that a stall cell should have a tendency to split into two cells as it grows. This tendency may be the reason for the observed trend in the number of cells. A. Betz, Germany

915. Ash, J. E., Investigations of three-dimensional cascades, WADC TR 55-158, 112 pp., May 1956. [Available from Off. Tech. Services, U. S. Dept. Commerce, Washington 25, D. C.]

The actual flow conditions within the passages of a 14-in. diameter four-bladed impeller of a mixed flow compressor have been investigated and compared with design values, which were based on axial symmetry and incompressible, nonviscous flow. The blades were designed as bound-vortex sheets, having a zero tangential component of vorticity, i.e., the velocity distribution in meridional planes is not disturbed by the blades. Flow surveys at the impeller outlet from hub to shroud and from blade to blade were made with a three-dimensional, spherical pitot probe mounted on

the impeller. This probe and also mercury seals for transferring the pressure signals from the rotating shaft to stationary manometers were especially developed for this investigation. Test runs conducted in the range from 1500 to 3000 rpm and from 8.7 to 44.1 cubic feet per second showed that the shape of the meridional velocity distribution between hub and shroud agrees essentially with the theory. However, in the blade-to-blade direction the distribution curves for the meridional velocity are displaced as much as 20% above and 10% below the average. Variations in the cone angle of the relative velocity are only in the order of 2° and 3°, i.e., the flow does not "twist" away much from surfaces of revolution. The median impeller slip factor was 0.57 within the test range.

The blade-to-blade distribution of the flow on the mean stream surface was also calculated by the relaxation method. It was found that the actual flow was more uniform than calculations showed. This may be due to the rapid reduction of the blade load near the tip and the shifting of low energy air toward the trailing face of the blades, observed for all test runs.

From author's summary by D. G. Shepherd, USA

916. Torda, T. P., Analysis of viscous incompressible and compressible flows through axial flow turbomachines with infinitesimal and finite blade spacing, WADC TR 55-231, 71 pp. + 5 tables + 29 figs., Mar. 1956. (Available from Off.Tech. Services, US Dept. Commerce, Washington 25, D. C.)

The Lorenz channel theory is developed for the analysis of viscous flows of a Newtonian fluid through turbomachines, first for incompressible fluids, then for compressible fluids. An iteration procedure is employed, the first step referring to an axially symmetric flow with infinitesimally spaced blades. The streamlines, as so calculated for a desired pressure rise and set of velocity triangles, are the infinitely numerous blades of the axially symmetric case. A particular set of these streamlines are then frozen and become the actual finite blades. The solution for the latter case is found from an infinite series of which the first term is the axially symmetric flow.

In its present state the theory is applicable only to laminar flows. Author concludes that "..... much numerical work has to be done to render the analysis useful for engineers. Only after such work has been carried out will it be possible to evaluate the usefulness of the theory presented."

A. H. Shapiro, USA

917. Morley, A. W., Compressor turbine matching of two-spool turboprops, *Aero. Quart.* **9,** 1, 17-33, Feb. 1958.

By simplifying expressions for component performance characteristics, author obtains useful algebraic relationships for approximate matching of two-spool compressor-turbine systems. Specifically, a relationship is found for the high-pressure compressor pressure ratio so that the high-pressure compressor nondimensional mass flow is constant.

Operation at this condition provides also a single operating curve for the low-pressure compressor which can avoid surge. Hence wide flexibility is obtained in engine operation. However, operation at the suggested pressure ratio implies a high sensitivity to intake temperature change. R. H. Eustis, USA

918. Hale, R. W., Aerodynamic tip theory of a supersonic propeller, Cornell Univ., Graduate School of Aero. Engng., ASTIA nos. AD 148116 and AD 148117, 67 pp., Feb. 1958.

The relative flow on propellor blades which is supersonic down to the root, where the region is bounded by an infinite cylinder, is calculated assuming that no vortex sheet is generated at the top. The three-dimensional flow near the tip is treated by a helical source potential in a similar way as Evvard [*NACA Reps.* 951, 1050] treated rectilinear supersonic flow.

A sample calculation of the pressure distribution over the blade tip consisting of a twisted flat plate is given. This method appears particularly useful for low-aspect-ratio low-solidity blades.

H. P. Eichenberger, USA

Flow and Flight Test Techniques and Measurements

(See also Revs. 878, 884, 902, 903, 954, 968, 1027, 1040)

919. Cable, A. J., Pressure measurement in armament research, *AGARD Rep.* 177, 4 pp. + 1 table + 6 figs., Mar. 1958.

A description is given of some typical pressure transducers (copper-crusher gages, piezo-electric transducers and strain-gage transducers) which have been developed and used at Aeronautic Research and Development Establishment for internal ballistics research. A quartz piezo-electric transducer and a modified piston-type strain-gage transducer are being used for pressure measurements in the ARDE Hypersonic Wind Tunnels.

From author's summary

920. Lacy, J. R., Interference effects between total pressure probes in the boundary layer of a supersonic wind tunnel, AFOSR TN 58-6 (Univ. Texas, Defense Res. Lab., Rep. 420; ASTIA AD 148 045), vii + 38 pp., Jan. 1958.

An experimental investigation was undertaken in a 6 × 6-in., Mach number 5 wind tunnel to determine the extent of any mutual interference effects between total pressure probes in supersonic flow. Blunt-nosed total pressure probes of 0.035-inch outside diameter were tested at several different positions in the wall boundary layer of the given wind tunnel. The results of these tests indicated the definite presence of mutual interference between total pressure probes at a spacing between probes of approximately 0.025 to 0.030 inch. An approximate method of determining shock wave shape and location ahead of plane and axially-symmetric bodies was utilized to provide an indication of minimum probe spacing to prevent mutual interference between probes of other sizes. From author's summary

921. Bollinger, L. E., and Edse, R., A direct measurement technique of determining rocket exhaust velocities, WADC TR 56-336 (ASTIA AD 110 500), 42 pp., Nov. 1956.

Efficiency of rocket engines and propellants depends upon the exit velocity of the exhaust gases. Direct measurement of velocity can supplement or replace other performance measurements. Authors measured exhaust velocity in the jet by injecting a pulse of an optical tracer material in the combustion chamber and observing the propagation velocity of the resulting luminous blob in the jet. Observation was done with photomultiplier tubes stationed along the jet, with the tubes triggering electronic chronographs to time the propagation of the light pulse.

The results obtained indicate that it is feasible to measure velocities in small hot jets at velocities of 9000 fps with reproducibilities of about ±2% maximum error.

The method needs further refinement for use in rockets with diverging or converging jets with shocks (nonideal nozzles), and is ultimately limited by the sharpness of "luminosity front" that can be produced in the flow. The method may prove easier to apply accurately in rockets larger than that used by the authors, since decreased velocity gradients in the jet are smaller in large rockets, thereby resulting in less velocity change between observation points and less involvement of shock patterns.

E. W. Price, USA

922. Nadporozhskii, I. I., Automatic gauge for measuring water flow levels (in Russian), *Sudostroenie* no. 6, 31–33, 1956; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5840.

An automatic gage is described for determining the level of a water flow, based on the principle of maintaining constant contact between the edge of the measuring needle and the surface of the water. The electrical part of the apparatus consists of a controlling differential set-up, an electronic amplifier, a phase-sensitive thyratron rectifier and a reversing motor. The electrical set-up of the apparatus does not differ appreciably from the scheme published earlier for a water-level indicator [*Electronics* March, 1940; for a translation of the paper see Markus, Tselyuf. "Technical applications of electronic valve schemes, Moscow, Izd-vo in. lit., 1954, page 246]. The principal design of the electrical part of the apparatus, the constructional design of the mechanical part and two photographs of the general lay-out are given. Data for the details of the electrical set-up are not furnished. The apparatus can be used in investigations on hydraulic models, as the amount of disturbance of the free water surface is slight while the guarantee for the precision of the measurements is sufficient.

N. A. Chernova

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

923. Markhasin, I. L., and Fakhreev, I. A., Recording device for the constant volumetric discharge of a liquid (in Russian), *Novosti Neft. Tekhn. Neftepromusl. dela* no. 5, 25–26, 1956; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5833.

A brief description is given of a recording device for the constant volumetric velocity of the movement of a liquid. An even change of the volumetric velocity in the range from 0.01 to 20 cm^3/hour when working in atmospheric conditions is possible. The transmitter is intended for guaranteeing a constant volumetric velocity when investigating the filtration of liquids through a porous medium, and can be used for work in the presence of general pressure in a hydraulic system up to 200 kg/cm^2. The movement of the liquid takes place under the action of a load and is controlled by a clockwork device. The liquid is expelled by an immovable piston from a cylinder. The cylinder changes position by means of a suspended weight and with the aid of a small rope attached to the reducing gear of the clockwork device. The principal features of the design are given.

T. B. Kurova

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

924. Sergievskaia, E. N., New principles of flow measurement (in Russian), *Teploenergetika* **4,** 1, 52–53, Jan. 1957.

925. Senshina, K. A., Measurement of pulsating flows with pitometric (inclined) scale, instantaneous readings and plotting of a diagram (in Russian), *Gidrotekh. Stroit.* **26,** 12, 38–39, Dec. 1957.

926. Lippisch, A. M., Flow visualization, *Aero. Engng. Rev.* **17,** 2, 24–32, 36, Feb. 1958.

927. Archbold, M. J., A visual qualitative approach to duct design for power plants, *Combustion* **29,** 10, 34–40, Apr. 1958.

928. Hasen, A. M., The application of a glow discharge to the measurement of the turbulent velocity pulsations of an airstream (in Russian), *Sb. statey nauch.-stud. o-va Mosk. energ. in-ta* no. 9, 163–172, 1956; *Ref. Zh. Mekh.* no. 3, 1957, Rev. 3316.

A thermoanemometer is described in which a glow discharge between platinum electrodes is used. The arrangement of the instrument is explained. The possibility is indicated of using the instrument for recording pulsations of a velocity, measuring the mean square deviation, and determining the frequency spectrum. Unfortunately, author suggests that, in its present state of development, the instrument is only suitable for qualitative determinations. The anemometer with a glow discharge has been described previously [C. Lindvall, *Elect. Engng.* no. 7, 1934; Yu. G. Zakharov, *Trudi CAHI* no. 599, 1946, etc.], but hitherto it has not been possible to obtain any quantitative results with such an instrument.

E. M. Minskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

929. Fournier, P. G., Wind-tunnel investigation of the high-subsonic static longitudinal stability characteristics of several wing-body configurations designed for high-lift-drag ratios at a Mach number of 1.4, *NACA TN* 4340, 9 pp. + 15 figs., July 1958.

The Mach number range was 0.60 to 0.95 with a corresponding Reynolds number of 2.0×10^6 to 3.3×10^6 based on mean aerodynamic chord. The basic highly swept (approximately 60° at c/4) wing had a taper ratio of 0.167, an aspect ratio of 2.91, and thin NACA 65-A-series airfoil sections. Other wings, of the same planform, had twist and camber and twist. All bodies were of elliptical cross section; the basic body had a Sears-Haack area distribution and the others had indentation for a Mach number of 1.4. The maximum angle-of-attack range was from −2° to 22°.

From author's summary

930. Fletcher, H. S., Low-speed experimental determination of the effects of leading-edge radius and profile thickness on static and oscillatory lateral stability derivatives for a delta wing with 60° of leading-edge sweep, *NACA TN* 4341, 11 pp. + 29 figs., July 1958.

Six delta-wing models with 60° of leading-edge sweep were oscillated about their vertical axes to determine the effects of systematic variation of leading-edge radius and profile thickness on the in-phase and out-of-phase combination lateral stability derivatives resulting from the motion. The results showed that, in general, increasing the leading-edge radius caused noticeable decreases in all the derivatives and increasing the airfoil thickness reduced the effective-dihedral parameter.

From author's summary

931. Meyer, C. H., Flight testing for inertial coupling characteristics, *AGARD Rep.* 124, 8 pp., May 1957.

The quest for high-speed and high-altitude performance has led to low-drag configurations in which a large proportion of the total mass of the aircraft is concentrated in the fuselage. The effect of this has been to increase the yawing and pitching moments of inertia and to reduce rolling moment of inertia, resulting in increased roll instability and finally in roll divergence. The causes and effects of roll divergence are discussed and possible approaches to the practical solution of the problem in the design of aircraft for specific roles are considered.

From author's summary

932. Widmayer, E., Jr., Clevenson, S. A., and Leadbetter, S. A., Some measurements of aerodynamic forces and moments at subsonic speeds on a rectangular wing of aspect ratio 2 oscillating about the midchord, *NACA TN* 4240, 27 pp. + 7 tables + 11 figs., May 1958.

Paper gives measurements made of the aerodynamic forces and moments acting on a rectangular wing of aspect ratio 2 which was oscillated about the midchord. These measurements were made at four frequencies (31, 43, 54, and 62 cps) over a range of Mach number from 0.15 to 0.81, a range of reduced frequency from 0.15 to 1.32, and a range of Reynolds number from 0.60×10^6 to 9.21×10^6. Reasonable agreement was found with previous experimental data. Comparison of the measured aerodynamic forces and moments with those predicted by the method of Reissner and by the method of Lawrence and Gerber for wings of aspect ratio 2 in in-

compressible flow showed generally good agreement. Authors remark that the effects of finiteness of span are considerable.

G. Temple, England

933. Gaukroger, D. R., and Chapple, E. W., Wind-tunnel tests on the effect of body freedoms on the flutter of a model wing carrying a localised mass, *Aero. Res. Counc. Lond. Rep. Mem.* 3081, 11 pp. + 46 figs., 1958.

Wind-tunnel test results for the flutter of a sweptback wing carrying a localized mass, and having symmetric or antisymmetric freedoms of the root, are given. The tests were made on a model wing of 23-deg sweepback, the chordwise and spanwise positions of a localized mass being varied for two localized mass values. In most of the symmetric flutter tests the inertia conditions of the fuselage were constant, and representative of full scale. For the antisymmetric tests, the fuselage rolling moment of inertia was varied.

The test results indicate that, in general, the symmetric flutter case is more critical than the antisymmetric for masses at outboard positions on the wing, but for heavy inboard masses the antisymmetric case may be the more critical. The results are too complex for any detailed use in predicting the effects of mass loading on the flutter of particular aircraft.

From authors' summary

934. Haines, A. B., and Rhodes, C. W., Tests in the Royal Aircraft Establishment 10-ft × 7-ft high-speed tunnel on 50-deg sweptback wings. I. Three of 7.5 per cent thickness. II. One of 7.5 per cent thickness with stall fences and leading-edge chord extension, *Aero. Res. Counc. Lond. Rep. Mem.* 3043, 52 pp. + 4 tables + 57 figs., 1957.

Tests have been made in the Royal Aircraft Establishment 10-ft × 7-ft high-speed tunnel on three half-wings having a sweepback of about 50 deg on the quarter-chord line and 7.5 per cent thick sections. Two of the wings had sections of the RAE 101 shape (maximum thickness at 0.31*c*) and differed principally in aspect ratio (3.1 and 3.5). The third wing had an aspect ratio of about 3.1 but a different section shape, with its maximum thickness further aft at 0.4*c* and, as shown by the results of the tests, an effectively sharper nose than for the RAE 101 shape.

Lift, drag, pitching moment and root bending moment were measured on all three wings over a range of Mach numbers from 0.50 to about 0.95 at a Reynolds number of about 2×10^6, and also for the two wings of smaller aspect ratio for three Reynolds numbers up to about 6×10^6 at a Mach number near 0.2. The flow patterns at low Mach number were investigated at $R = 2.6 \times 10^6$ and, in one case, at $R = 6 \times 10^6$ also, by an oil-film technique. A description of the technique and of how the flow patterns were interpreted is included. Two of the wings were also tested with surface tufts at various Mach numbers up to $M = 0.94$.

From authors' summary

935. Johnson, J. L., Jr., Wind-tunnel investigation at low speeds of flight characteristics of a sweptback-wing jet-transport airplane model equipped with an external-flow jet-augmented slotted flap, *NACA TN* 4255, 17 pp. + 13 figs., July 1958.

936. Tolhurst, W. H., Jr., Full-scale wind-tunnel tests of a 35° sweptback-wing airplane with blowing from the shroud ahead of the trailing-edge flaps, *NACA TN* 4283, 12 pp. + 2 tables + 14 figs., July 1958.

Data are presented showing the effect of flap position relative to the blowing nozzle on the air-flow requirements for boundary-layer control on flaps deflected from 45° to 75° at a Reynolds number of 7.5×10^6. A direct comparison of shroud blowing and flap blowing is shown for a plain flap configuration. Also presented are data showing the effect on the air-flow requirements of spacers in the nozzle, discontinuities on the flap upper surface, and of sealing the slot when the flap was in the single-slotted flap configuration.

From author's summary

937. Kuehnel, H. A., and Sommer, R. W., Flight investigation of the acceptability of a small side-located controller used with an irreversible hydraulic control system, *NACA TN* 4297, 7 pp. + 2 tables + 10 figs., July 1958.

938. Chinneck, A., and North, Mrs. N. A., Some tests in a slotted-wall tunnel with various slot-entry shapes, *Aero. Res. Counc. Lond. Curr. Pap.* 377, 4 pp. + 13 figs., 1958.

939. Williams, J. L., Wind-tunnel investigation of effects of spoiler location, spoiler size, and fuselage nose shape on directional characteristics of a model of a tandem-rotor helicopter fuselage, *NACA TN* 4305, 11 pp. + 20 figs., July 1958.

The results of a low-speed investigation in the Langley stability tunnel on a model of a tandem-rotor helicopter fuselage showed that spoiler size, spoiler location, and fuselage nose shape were important factors in the directional stability characteristics of the fuselage-tail configuration. Tuft-grid pictures showed that the tail operated in an adverse flow field that resulted in a low tail effectiveness.

From author's summary

940. O'Bryan, T. C., Flight measurements of the vibratory bending and torsional stresses on a modified supersonic propeller for forward Mach numbers, *NACA TN* 4342, 9 pp. + 8 figs., June 1958.

Vibratory bending stresses, measured in flight, on a modified supersonic propeller were low in relation to the strength of the material. The vibratory torsional stresses did not exceed ±1,000 pounds per square inch.

From author's summary

941. Hudimoto, B., and Kubota, S., The wind tunnel tests of the steam- and gas-turbine blades, *Bull. JSME* **1**, 1, 50–56, Jan. 1958.

Experiments on the flow through cascade of steam turbine blades were recently carried out and the results obtained are summarized in this report. All of the experiments were carried out on the blade profiles of the impulse-type turbine, and investigations were made on the following subjects.

(1) Comparison of the performances of the several typical blade profiles,

(2) Effect of the blade turning angle,

(3) Effect of Reynolds number and the blade surface roughness,

(4) Effect of the boundaries of jet from the turbine nozzle.

From authors' summary

942. Westphal, W. R., and Maynard, J. W., Jr., Design and tests of a six-stage axial-flow compressor having a tip speed of 550 feet per second and a flat operating characteristic at constant speed, *NACA TN* 4253, 19 pp. + 2 tables + 15 figs., June 1958.

The six-stage axial-flow compressor was designed for a constant power input per pound of flow with a design specific weight flow of 21.3 pounds per second per square foot of frontal area at atmospheric discharge with a stagnation-pressure ratio of 3.25 and an inlet hub-tip radius ratio of 0.7. Several configurations having different blade setting angles and solidities were tested. The tests showed that the design flow, pressure ratio, and flat stagnation-pressure ratio as a function of weight flow were obtained at a peak efficiency of 82.8%.

From authors' summary

943. Enkenhus, K. R., The design, instrumentation and operation of the UTIA low density wind tunnel, *Univ. Toronto Inst. Aerophys. Rep.* no. 44, 81 pp. + 3 appendices + 50 figs. + 16 plates + 6 tables, June 1957.

The UTIA low-density wind tunnel is a continuous, open circuit tunnel with vacuum pump drive designed to operate at Mach numbers up to 5 over a range of low pressures suitable for the study

of rarefied gas flows. Booster-type oil diffusion pumps are used to provide a range of operating pressures from 0.001 to 0.070 mm Hg. The Reynolds number per inch is from 0.1 to 4×10^3.

The two parts of the report following the introduction deal with the design, construction and instrumentation of the tunnel. The subject of part 4 is wind-tunnel operation, including the method of nozzle calibration and a discussion of low density effects on pressure probes. Section 5 is devoted to a theoretical study of conventional nozzles and slotted wall nozzles with boundary-layer suction.

The calibration of axisymmetric nozzles for Mach 4, Mach 2 and subsonic flow is given in the last section. These nozzles have solid walls and were operated at pressures of 0.040, 0.020 and 0.008 mm Hg, respectively. The flow in the supersonic nozzles is essentially a continuum flow at low Reynolds number with the boundary layer filling most of the jet, while in the subsonic nozzle the density was low enough to produce slip on the walls.

New studies of outgassing effects on pressure probes in free molecule flow are given in an appendix. A bibliography of low density references is included in the report.

From author's summary

944. King, J. L., Boyle, P., and Ogle, J. B., Instability in a slotted wall tunnel, *Aero. Res. Counc. Lond. Curr. Pap.* 343, 12 pp. + 12 figs., 1957.

Paper describes an experimental and theoretical investigation of flow instability resulting in pressure fluctuations in a slotted wind tunnel of circular cross section. The work was aimed at understanding instability in a slotted water tunnel, and the tests in air were accordingly made at low Mach number.

It is shown theoretically that a circular jet is unstable when moving through the same fluid, and experimental results indicate that the slotted wall does not stabilize all frequencies of disturbance. The length of the working section is shown to determine preferred wave lengths of disturbance, and it is suggested that the disturbances feed energy back to the upstream end of the jet by compressing the fluid in the reservoir surrounding the working section. When the reservoir is removed, the instability disappears. D. W. Holder, England

945. Parkin, B. R., Experiments on circular-arc and flat-plate hydrofoils, *J. Ship Res.* **1**, 4, 34–56, Mar. 1958.

An investigation in the high-speed water tunnel of the two-dimensional hydrodynamic characteristics of sharp-edge hydrofoils is described. The lift, drag, and pitching moment were measured in cavitating and noncavitating flows for flat-plate and circular-arc profiles. The theory of Wu for the forces on sharp-edge profiles in full-cavity flow and the experimental results showed good agreement over a wide range of attack angles.

From author's summary

Thermodynamics

(See Revs. 628, 757, 897, 998, 1009, 1018, 1020, 1077, 1099)

Heat and Mass Transfer

(See also Revs. 606, 613, 683, 854 855, 878, 887, 1002, 1011, 1015, 1033, 1034, 1035, 1066, 1088, 1090, 1096, 1099)

Book—946. Jakob, M., Heat transfer, (Vol. II), New York, John Wiley & Sons, Inc., 1957, xxxii + 652 pp.

We must be thankful to a fate which allowed Professor Max Jakob to finish, during his lifetime, the second volume and in this way to complete his treatise, "Heat Transfer." Jakob was uniquely equipped for such an endeavor because he was active in heat-transfer research since the earliest developments of this science. During his earlier years, he worked in Germany at various research institutes which contributed much to the initiation and growth of heat transfer as a basic branch of the science of thermodynamics. His moving to this country enabled him to acquaint himself with work which had been done here up to that time, to follow its development closely, and to participate actively in research during the time when the center of activities in heat transfer shifted to the United States. Jakob's methodical and thorough nature obviously induced him to keep extensive records over all these periods. As a consequence, we can now enjoy a treatise which, in two volumes with a total of 1410 pages, not only covers the whole field of heat transfer on a unified basis, but also records the history of this science in a way that is seldom available in other areas.

The second volume consists of the following parts: F. Heat radiation in spaces of simple configuration, G. Selected fields of application, H. Supplements to volume I, and a number of Appendices covering problems, nomenclature, conversion of units, bibliography, and indices.

The following topics are covered:

Part F: Analytical methods to determine heat exchange by radiation between various surfaces of an enclosure filled with a non-absorbing medium. Net radiation method by Poljak. Integral equations describing radiation exchange. Experimental methods to obtain the geometric relations evolved in radiative exchange calculations. Radiation properties of surfaces. Radiation of gases. Radiation of gases carrying solid particles.

In part G: Heat transfer connected with thermometry and analysis of errors by conduction, radiation, incomplete energy recovery, and by heat capacity. Radiation pyrometry. Hot-wire anemometery. Recuperative heat exchangers with various flow arrangements. Regenerative heat exchangers for single or continuous operation. Cooling tower theory based on Merkel's and Mickley's developments. Special cooling methods which have been developed to protect surfaces exposed to hot gases like water walls in combustion chambers of steam boilers, cooling methods for gas turbine blades, and transpiration cooling. Heat transfer connected with high velocity boundary-layer flow for laminar and turbulent condition. Heat transfer in liquid metals. Heat transfer in packed columns.

Part H. presents material supplementing the content of the first volume.

In this volume and especially in part G, Jakob used the method to select a few papers which he considered as an especially concise presentation of the respective field and to follow in the discussion the reasoning of these papers, in some cases quite closely. This he obviously considered as the best solution when confronted with the large amount of information which has accumulated in various areas of heat transfer as a consequence of research in recent years. In a work of this size, some minor deficiencies are unavoidable. Reviewer noted, for instance, that the energy equation (39.18) on page 422 for a compressible fluid does not contain a term describing work performed by expansion and that in the discussion on page 393 of a method by E. R. G. Eckert and T. W. Jackson, which analyzes turbulent free convection boundary-layer flow, some misrepresentation of the basic reasoning has occurred. Such a remark, however, should not detract from the importance of this work. It is felt that both volumes will be found as a necessary tool on the bookshelf of anyone who is engaged in research in heat transfer or in the application of its results. E. R. G. Eckert, USA

947. Goldberg, M., Prediction of vacuum tube bulb temperatures, ASME-AIChE Joint Heat Transfer Conf., Chicago, Ill., Aug. 1958. Pap. 58-HT-13, 15 pp.

Paper is an attempt to provide the electrical engineer or electrical designer with sufficient heat-transfer information to provide

some guidance on the bulb temperature and derating problems. Data on the heat transfer from vacuum-tube amplifiers to a coolant, such coolant being in longitudinal flow along the vacuum tubes, are presented. The results obtained by experiment indicate that a dimensionless correlation concerning the Stanton, Reynolds, and Prandtl numbers can be established. Methods of evaluating the heat-transfer coefficient and both average and maximum tube-envelope temperature are presented in the case of a vacuum-tube amplifier containing subminiature triodes.

From author's summary

948. Timo, D. P., and Goldhoff, R. M., The calculation of forging cooling rates, ASME Semiann. Meet., June 1958. Pap. 58-SA-4, 11 pp.

Problem of cooling of a heated cylinder in contact with a fluid with constant bulk temperature is discussed. Heat transfer within the cylinder is by conduction; heat transfer between the cylinder and the medium is described by a surface heat transfer coefficient h. Both h and the thermal diffusivity α are temperature-dependent.

Authors start from known solution for constant h and α. The temperature dependence is taken into account by dividing the temperature range in a number of intervals and choosing averaging values of h and α for each interval. Temperature-versus-time curves are then obtained by combining appropriate portions of curves calculated for each combination of h and α. Phase transformations are accounted for approximately by assuming a rapid change of specific heat in the temperature region where the transformation takes place.

Calculated cooling curves agree well with experimental ones for two experiments, one for a cylinder with a diameter of 7 inches, the other a 44-inch diameter rotor forging. The agreement serves as an empirical justification of the validity of the approximations made in the analysis.

Reviewer thinks that the method needs a better mathematical justification before its validity can be accepted generally. For instance, no discussion is given of the results obtained for a different (say finer) division of the temperature region in intervals.

D. A. DeVries, Holland

949. Pokidov, N. A., Heat transfer during cooling of gas-turbine blades (in Russian), *Teploenergetika* **3,** 6, 59–61, June 1956.

950. Krukovskii, V. K., Temperature field in heating coal by electric current (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 6, 101–107, June 1956.

951. Dyban, E. P., Kondak, N. M., and Shvets, I. T., Comparative study of the cooling of disks in gas turbines by the flow of air in radial direction or through the bases of the blades (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 6, 77–88, June 1956.

Using the available published experimental data and supplementing them by theoretical deduction of the temperature distribution in disks of turbines, the efficiency of cooling by air flow is investigated. In particular a comparison is made of cooling systems in which the air flows in radial direction and systems where the flow is in tangential direction. It is found that the rate of heat transfer from the turbine to air could be appreciably increased if tangential flow is employed and the design of the disk is appropriately modified.

R. Eisenschitz, England

952. Litvinov, M. M., Determination of steady temperature fields in the blades and disks of turbines by an electric analogue method (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 5, 12–22, May 1956.

Author's analog computer consists of a solid model of the blade (or other component of turbines) made of conducting material which is suspended in an electrolyte. The transmission of heat is replaced by conduction of electricity. This apparatus is known as a means of solving problems in which the temperature of the surface is prescribed. In order to adapt it to problems in which a linear relation between the temperature and heat flow is prescribed on the surface of the blade, author uses supplementary surface layers to be attached to the model. The apparatus and its uses are described in detail.

R. Eisenschitz, England

953. Korenev, B. G., Steady temperature fields in a thin plate and rod supported by a continuous homogeneous foundation (in Russian), *Dokladi Akad. Nauk SSSR (N. S.)* **107,** 2, 225–228, Mar. 1956.

954. Stoney, W. E., Jr., and Markley, J. T., Heat transfer and pressure measurements on flat-faced cylinders at a Mach number of 2, *NACA TN* 4300, 21 pp. + 1 table + 16 figs., July 1958.

Flat-nosed circular cylinders of diameters 4 and 12 inches were tested in free jets at a Mach number of 2 and at sea level conditions. The velocity gradient at the stagnation point was found to be about 30% of the gradient on a hemisphere of equal diameter. The stagnation point heat-transfer rates were about 55% of those which would be measured on a hemisphere of equal diameter. The flow was entirely laminar on the face of the 4-inch model but turbulent over most of the 12-inch model. Laminar data compared well with theory, but the measured turbulent heat-transfer rates were lower than predicted by a theory derived from flat-plate theory.

N. H. Johannesen, England

955. Yuan, S. W., and Barazotti, A., Experimental investigation of turbulent pipe flow with coolant injection, Heat Transf. and Fluid Mech. Inst., Univ. of Calif., Berkeley, Calif., June 1958, 25–39.

Air was injected through porous walls of a pipe and measurements were made of axial pressure distribution, wall temperature, and of radial velocity and temperature profiles. Temperature range of main flow was between ambient and 900 F and Reynolds number was varied up to 300,000. Results show that profiles can be predicted if axial pressure gradient, maximum velocity at center of pipe, and an empirical constant are known from experiment. Statement is made that since wall-friction coefficient increases with coolant injection whereas heat-transfer coefficient decreases with increased injection, analog between heat transfer and momentum transfer does not exist in this type of flow. Reviewer notes that skin-friction coefficient is based on conditions upstream of injection and that if the coefficient were based on local properties, the coefficient would decrease with injection. Hence, conclusion regarding Reynolds analogy is questioned.

W. F. Davis, USA

956. Hanawalt, A. J., Blessing, A. H., and Schmidt, C. M., Thermal analysis of stagnation regions with emphasis on heat sustaining nose shapes at hypersonic speeds, Heat Transf. and Fluid Mech. Inst., Univ. of Calif., Berkeley, Calif., June 1958, 241–252.

The possibility of cooling the forward stagnation regions on a hypersonic glide vehicle by radiation exclusively is discussed. It is shown that by judicious shaping of the stagnation region and by consideration of the heat conducted from the region, stagnation temperatures can be kept down to about 3500 K. The laborious numerical calculations called for an IBM 704.

S. H. Maslen, USA

957. Hutcheon, I. C., and Spalding, D. B., Prismatic fin with non-linear heat loss analysed by resistance network and iterative analogue computer, *Brit. J. Appl. Phys.* **9,** 5, 185–190, May 1958.

The object of the study is to analyze the nonlinear heat transfer from a fin of uniform cross-sectional area. The heat-transfer co-

efficient varies as the fourth root of the difference in temperature between the fin and the ambient fluid. The differential equation for the temperature distribution is $d^2\theta/dy^2 = K\theta^{5/4}$ where θ is a nondimensional temperature difference between the fin and the fluid; y is a nondimensional distance from the base of the fin; and K is a constant which depends on the geometry, the thermal conductivity of the fin, and the difference in temperature between the base of the fin and the surrounding fluid.

The study makes use of a resistance analog network in conjunction with a new type of iterative analog computer which varies the electrical resistance representing the surface heat transfer resistance as the voltage in the analog network changes.

Results are given for the temperature distribution as a function of y and K for three fin geometries. A comparison of the fin efficiency for constant and variable heat-transfer coefficient shows that little difference exists for short fins. For longer fins the efficiency for the variable heat-transfer coefficient is somewhat less than for the case where the heat-transfer coefficient is considered to remain constant; however, the difference does not exceed 10%. E. Sunderland, USA

958. Hastrup, R. C., Sabersky, R. H., Bartz, D. R., and Noel, M. B., Friction and heat transfer in a rough tube at varying Prandtl numbers, *Jet Propulsion* **28,** 4, 259–263, Apr. 1958.

A set of experiments was carried out with the purpose of extending the available data on heat transfer in rough tubes as well as the information concerning the relationship between heat transfer and friction. The results are presented in terms of the heat transfer coefficient C_h and the friction coefficient C_f. Particular attention was paid to the effect of Prandtl number. The experiments were carried out in an electrically heated tube with water as a working fluid. By using water at various temperatures experiments could be performed over a continuous range of Prandtl numbers from about 1 to 7. For the tube and the type of roughness used in the experiments the results confirm that roughness increases the heat transfer as well as the friction coefficient, but that the ratio C_h/C_f decreases with increasing roughness. The latter effect seemed slightly more pronounced at the lower Prandtl numbers. From authors' summary

959. Wang, P.-H., Convective heat transfer for turbulent flow of single-phase fluid through concentric annuli (in Chinese), *Chinese J. Mech. Engng.* **6,** 1, 29–38, Mar. 1958.

As presented earlier, the preliminary experimental data on the heat-transfer coefficient at the inner wall for turbulent flow of water through concentric annuli of $d_2/d_1 = 1.84$ deviate from W. H. McAdams' and M. A. Mikheyevs' recommended formulas, yet agree with E. S. Davis' equation. This paper gives a general survey on heat transfer in turbulent flow of single-phase fluid through concentric annuli. Author concludes that, although numerous investigations of forced convective heat transfer in concentric annuli have been reported in the literature, appreciable inconsistencies in the published data have made the suggested correlations for heat-transfer coefficients at the inner wall uncertain. Further researches to clarify the subject from different aspects are suggested. From author's summary

960. Anantanarayanan, R., and Ramachandran, A., Effect of vibration on heat transfer from a wire to air in parallel flow, *Trans. ASME* **80,** 7, 1426–1431, Oct. 1958.

An experimental investigation of the effect of transverse vibration on the heat transfer to a wire parallel to a low speed flow was performed. Expetimental results were correlated in terms of a ratio of Nusselt numbers with and without vibration and of a ratio of Reynolds numbers, one based on mean vibrational velocity and the other on an air-stream velocity. Vibration is found to increase the heat transfer. P. A. Libby, USA

961. Sato, K., and Sage, B. H., Thermal transfer in turbulent gas streams—effect of turbulence on macroscopic transport from spheres, *Trans. ASME* **80,** 7, 1380–1388, Oct. 1958.

Results of an experimental investigation of over-all heat transfer to spheres in low speed flow at various free-stream turbulence levels are presented. Heat transfer is, as expected, increased by turbulence. Data are correlated in terms of a Nusselt number, Reynolds number and the root-mean-square longitudinal velocity fluctuation. P. A. Libby, USA

962. Seban, R. A., Chan, H. W., and Scesa, S., Heat transfer to a turbulent boundary layer downstream of an injection slot, ASME Ann. Meet., New York, N. Y., Dec. 1957. Pap. 57-A-36, 11 pp.

Adiabatic wall temperatures and heat-transfer coefficients are presented for a turbulent boundary-layer flow of air over a flat plate downstream of the point at which air is injected into the existing flow. Normal and tangential injections were examined and the results compared to those of Wieghardt for approximately tangential injection. Free-stream velocities were below 125 fps so that effects of flow dissipation were not included. Mass rates of injection air flow ranged from zero to a value equal to that of the free-stream flow. The results for the adiabatic wall temperature indicate a complicated dependence on the flow only partly accounted for in the correlation achieved. A postulate that the flow characteristics do not affect this temperature, so that the source can be idealized merely as a line source of heat, is not confirmed by these results. The results for the heat-transfer coefficient are far less affected by the changes in the flow due to injection and the results demonstrate that for a major region downstream of the slot these coefficients are close to those that exist for a turbulent boundary layer on a smooth flat plate.

From authors' summary by P. A. Libby, USA

963. Clifford, W. D., Effect of air temperature on vortex shedding frequency of cylinders, *J. Aero. Sci.* **24,** 11, p. 852 (Readers' Forum), Nov. 1957.

964. Inaiatov, A. Ya., and Mikheev, M. A., Heat transfer by water flowing along a pipe bank (in Russian), *Teploenergetika* **4,** 3, 48–50, Mar. 1957.

965. Tirskii, G. A., Effect of gas flow on temperature distribution of heat in nonuniform bars with varying cross section (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 1, 70–76, Jan. 1957.

The problem, considered as one-dimensional, leads to solving an ordinary differential equation of the second order, with variable coefficients. After transforming the equation, author uses for its solution the method of a small parameter: the unknown function is assumed in the form of a finite series in power of the small parameter ϵ. First of all, author finds an approximate solution of the homogeneous equation, then of the nonhomogenious one, simultaneously with the estimation of the error. Author then presents a numerical example, estimates the error caused by using the approximate method and shows that this error can be made as small as we like. An analysis of the results obtained is presented at the end. K. Rektorys, Czechoslovakia

966. Trefethen, L., Fluid flow in radial rotating tubes (in English), 9th Congrès Intern. Mecan. Appl., Univ. Bruxelles, 1957; **2,** 341–350.

Author compares three different cases of flow of liquids; (a) in bent tubes, (b) in horizontal heated tubes, and (c) in radial rotating tubes. In all these cases a double helix secondary flow is caused by unbalanced forces acting perpendicularly to the axis of the primary flow. Distortion of velocity profile, transition of critical *Re* number, as well as an increase of friction losses and heat-transfer coefficient are similar in all these cases, independent of the na-

ture of the body forces. Dimensionless parameters $N = Re\,(d/D)^{1/2}\,(Gr/2)^{1/2}$ and $(\mathrm{Re}\;\omega\,d^2/\nu)^{1/2}$ have been introduced to enable the comparison of the data taken from literature in cases (a) and (b) and obtained experimentally by author for rotating tube in case (c). It would be interesting to carry out the tests for larger range of numbers N and Re, respectively.

O. Mastovsky, Czechoslovakia

967. Byzova, N. L., The self-induced oscillations of a heat convection flow (in Russian), *Trudl Mor. gidrofiz. in-ta, Akad. Nauk SSSR* **6,** 58–79, 1955; *Ref. Zh. Mekh.* no. 3, 1957, Rev. 3190.

The temperature and velocity fluctuations in a convection flow are studied. The flow was set up in a rectangular, open vessel; the heater (electric) was placed under one half of the bottom of the vessel, while the other half was cooled. Three models were used; the smallest had dimensions of 100 × 10 × 30 cm. The temperature in the flow was measured by means of thermocouples, the velocity of the liquid was determined by the observation of suspended particles. Other methods were also used (shadowgraph, dyeing, etc.)

The fundamental results were published by the author earlier [*Dokl. AN. SSSR*, 1950, **72,** (4); *Izv. AN. SSSR, ser. geofiz.* 1951, no. 5].

E. M. Zhukhovitskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

968. Dmitriyev, A. A., An analysis of the light polarization pattern of thermal circulation (in Russian), *Trudl Mor. gidrofiz. in-ta, Akad. Nauk SSSR* **4,** 143–158, 1954; *Ref. Zh. Mekh.* no. 3, 1957, Rev. 3197.

A theoretical and experimental investigation is described of the thermal circulation in particular idealized conditions. A light polarisation pattern is obtained of the circulation of a fluid in a rectangular parallelipiped, formed by the combined action of one or several pairs of coolers and heaters.

A diagram of the streamlines has also been constructed, as observed from the motion of (suspended) particles. A theoretical analysis is made of the motion of an incompressible fluid between two coaxial cylinders. The liquid is bounded above and below by flat surfaces, perpendicular to the axis of the cylinders. Having calculated the circulation arising from the action of the rotation of the outer cylinder and the covering surfaces, author gives an analytical confirmation of the experimental results obtained by Ya. V. Mamuhl [*Zh. Tekhn. Fiz.* **6,** no. 11, 1936] according to which the streamlines between two coaxial cylinders have the form of spirals tending to coincide with the circumferences at increasing speeds of rotation.

A. S. Sarkisyan

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

969. Petukhov, B. S., Krasnoshvhekov, E. A., and Nol'de, L. D., Heat transfer during viscous flow of fluids in tubes and channels (in Russian), *Teploenergetika* **3,** 12, 41–47, Dec. 1956.

970. Rukenshtein, E., Equations of heat transfer in turbulent flow in pipes (in Russian), *Izv. Akad. Nauk. SSSR, Otd. Tekh. Nauk* no. 5, 23–28, May 1956.

Rukenshtein considers equation of heat transfer in a turbulent flow in pipes. After introducing the notion of the mean temperature in a cross section and of the heat flux and modifying the heat equation correspondingly, Rukenshtein discusses characteristic numbers of the system: Prandtl and Nusselt numbers.

M. Z. v.Krzywoblocki, USA

971. Bertram, M. H., and Henderson, A., Jr., Effects of boundary-layer displacement and leading-edge bluntness on pressure distribution, skin friction, and heat transfer of bodies at hypersonic speeds, *NACA TN* 4301, 15 pp. + 19 figs., July 1958.

Paper reviews and compares theoretical and experimental results concerning effects mentioned in title. Reference is made to 20 published reports and considerable additional material is presented.

Survey-character of paper makes a detailed review difficult, but reviewer agrees with the authors' conclusion that "The results presented indicate that much of the viscous and nose-blunting phenomena that have been studied in the past in a rather academic way are now understood to the point where engineering estimates of many of their effects are now possible. However, a large area for additional research remains to be explored."

N. H. Johannesen, England

972. Scala, S. M., Hypersonic heat transfer to catalytic surfaces, *J. Aero. Sci.* **25,** 4, 273–275 (Readers' Forum), Apr. 1958.

973. Libby, P. A., and Cresci, R. J., Evaluation of several hypersonic turbulent heat transfer analyses by comparison with experimental data, Polyt. Inst. Brooklyn, Dept. Aero. Engng. Appl. Mech., WADC TN 57-72 (ASTIA no. AD 118093), 37 pp., July 1957.

Paper comprises two main parts: (1) Presentation of results of pressure and local heat-transfer measurements by the shrouded-model technique for laminar, transitional, and turbulent flow on a model consisting of a portion of a sphere; (2) Comparison of the measurements for turbulent flow with six different theories. The measurements extended from stagnation point to the point of 0.75 Mach number. Stagnation-to-wall enthalpy ratios were varied from about 2 to 1.4. Reynolds numbers were varied over a 6-fold range.

The comparison of experiments and theories for turbulent flow is quite illuminating. The differences between the various theories amount to a factor of about 5 to 1, whereas no perceptible effect of enthalpy ratio was noted. Two of the methods, one very simple to use (intermediate enthalpy method), were in reasonable agreement with the measurements.

D. R. Chapman, USA

974. Darevskii, S. G., Transmitters for measuring the temperature of high-speed gas flow (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **107,** 3, 373–376, Mar. 1956.

975. Hammitt, F. G., Modified boundary-layer-type solution for free-convection flow in vertical closed tube with arbitrarily distributed internal heat source and wall temperature, ASME Semiann. Meet., Detroit, Mich., June 1958. Pap. 58-SA-30, 24 pp.

Analytical solution is obtained for the cooling of fluid with volumetric heat generation in a closed vertical tube with cooled walls, by means of free convection and wall conduction. The solution applies for large heating densities in fluids of Prandtl number near unity, as expected in aqueous homogeneous internally-cooled nuclear power reactors. Arbitrary wall temperature and axial distribution of heating density are included.

Solution was obtained by trial-and-error double iteration, on a 650 computer, to satisfy the condition of zero boundary-layer thickness at both ends. Heat transfer coefficients obtained for constant wall temperature and heating density are approximately half as high as those computed by Lighthill for the case of the tube being open on top to a reservoir of cold fluid, and having no heat generation.

C. F. Bonilla, Puerto Rico

976. Slavnov, V. V., Free heat convection in round vertical metal pipes (in Russian), *Zh. Tekh. Fiz.* **26,** 9, 2002–2004, Sept. 1956.

977. Orakhlin, E. Kh., The free, steady-state heat convection in a spherical cavity in the absence of a threshold (in Russian), *Uch. zap. Molotovsk. in-ta* **9,** 4, 29–39, 1955; *Ref. Zh. Mekh.* no. 3, 1957, Rev. 3183.

The problem is solved approximately of the steady-state convection in a liquid or gaseous medium filling a spherical cavity in a

mass, in the presence of specified temperature gradient in the mass at infinity, having any arbitrary direction except the vertical. The problem is regarded as two-dimensional. The temperature distributions are determined in the liquid and in the mass in the null and first approximations, and the hydrodynamic velocities of the medium in the first and second approximations. The solution of the equations is performed by the method of successive approximations founded on resolution of the solutions by powers of the Grashoff number. S. B. Gerasimova

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

978. Romanov, A. G., Investigating heat exchange in a dead-end duct under natural convection conditions (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 6, 63–76, June 1956.

Paper contains theoretical analysis and experimental verification of the problem of heat exchange between a cooling medium and a hollow turbine blade. Analytical approach makes use of dimensional analysis as well as integral theory of boundary layer in a hollow turbine blade. Interestingly enough, it is assumed that cooling medium could be different than air. Experiments have been conducted both on stationary blades in gravitational field and on blades attached to rotating turbine disk. Agreement of heat-transfer coefficients with theoretical results appears satisfactory in all ranges of operation. Author seems to be aware of early work done by NACA in similar connection and his criticism of correlation method used by it deserves some attention. He suggests correlation method which would bring NACA experimental results into agreement with theoretical expressions for Nusselt number in hollow blade. This reviewer would like to indicate that later extensive work done by NACA, of which the author does not seem to be cognizant, has resolved this problem.

B. Zarwyn, USA

979. Dmitriev, B. A., Transmission of heat in free convection during cooling of the blades of gas turbines by means of liquids (in Russian), *Izv. Akad. Nauk. SSSR, Otd. Tekh. Nauk* no. 5, 103–107, May 1956.

Using a simplified model theoretical calculations of the heat transfer in free convection had been made. They agreed with experiment in the range of laminar flow but disagreed under conditions of turbulence. In the present paper the theoretical deductions are revised in such a way that the distribution of velocity and temperature comply with additional boundary conditions. As a result Nusselt's number is obtained in dependence of a simple function of the Grashof and Prandtl numbers. Agreement with experiment is improved. R. Eisenschitz, England

980. Knuth, E. L., Compressible Couette flow with diffusion of a reactive gas from a decomposing wall, Heat Transf. and Fluid Mech. Inst., Univ. of Calif., Berkeley, Calif., June 1958, 104–113.

Paper gives analysis of steady compressible viscous Couette flow (i.e. flow characterized by two parallel plates in relative motion to each other) with mass-transfer cooling, a decomposing wall, and diffusion of the reactive gas from the wall. The case of tetrafluoroethylene diffusing into the air stream is considered. The coolant gas is assumed to react with the oxygen in the air according to the formula $C_2F_4 + O_2 \rightarrow 2COF_2$. Combustion is essentially assumed to occur in a thin sheet, coolant and oxygen being diffused into, and combustion products away from, this sheet. Velocity of the moving surface, and temperature and partial pressures at this surface, are considered as specified. Analysis consists of integrating equations of conservation of mass (for each specie), momentum and energy, taking into account boundary conditions at the flame sheet and at the moving and stationary surfaces. Infinitely fast chemical reaction rate is assumed, but suitable modification also gives results for infinitely slow reaction rate. Final equations determine, in principle, mass-transfer rates, shear stresses, heat-transfer rates, partial pressures, velocities and temperatures. Results of a numerical example are shown. It is indicated that a decomposing surface may be extremely effective in reducing the equilibrium temperatures of surfaces exposed to high-speed air streams even if the decomposition products react exothermically. M. Morduchow, USA

981. Aref, M. N., Emissivity measurement of industrial surfaces due to thermal radiation, ASME-AIChE Joint Heat Transfer Conf., Chicago, Ill., Aug. 1958. Pap. 58-HT-18, 15 pp.

In the field of physical constants, the measurement of surface emissivity at elevated temperatures has been done by heating up the surface either directly or in a furnace, while keeping the instrument measuring the surface emissivity at room temperature. Apparently, this technique was used due to the lack of a reliable, calibrated high heat-resistant device that would measure the radiant heat flux from the hot surface in the furnace. However, if such a device were available, then the errors involved in the measurement of the surface radiation and the time lag of the earlier instrument can be eliminated. Author presents a new technique in which a calibrated probe radiometer is employed. For the sake of comparison with the new technique, a variation of the earlier technique has been included in this discussion.

From author's summary

982. Zinzen, A., and Schubert, F., New approach for evaluating experiments on natural water circulation in steam boilers (in German), *Brennstoff-Wärme-Kraft* **10,** 5, 216–218, May 1958.

Observations have shown that gas bubbles rising in water carry along a considerable quantity of water. A new equation for the evaluation of tests on water circulation is given with regard to this effect. It is possible now, at least qualitatively, to compare results by different authors and to explain arising anomalies.

From authors' summary

983. Chernobyl'skii, I. I., and Tananaiko, Yu. M., Heat exchange during the boiling of liquids in an annular aperture (in Russian), *Zh. Tekh. Fiz.* **26,** 10, 2316–2322, Oct. 1956.

984. Korneev, M. I., and Puganov, B. N., Investigation of heat transfer in the flow of a vapor-fluid mixture in horizontal tubes (in Russian), *Teploenergetika* **3,** 6, 39–44, June 1956.

985. Reerink, H., Dorgelo, C. H., and Kramers, H., Heat transfer in the evaporation of sugar solutions in a vertical single-tube evaporator (in English), *Ingenieur* **70,** 24, 11–14, June 1958.

Over-all heat-transfer coefficients have been determined for the continuous concentration of sugar solutions by evaporation in a pilot-plant-scale single-tube evaporator (I. D. 47 mm, length 2 m). Both natural circulation and single pass operation have been investigated. It has been found that with concentrated solutions and at a high evaporation rate the latter way of operation gives the best heat-transfer coefficients.

From authors' summary

986. Spangemacher, K., Calculation of cooling towers and injection coolers by means of an evaporation coefficient (in German), *Brennstoff-Wärme-Kraft* **10,** 5, 209–215, May 1958.

Calculation and evaluation of cooling towers, as recommended by Merkel, are critically examined. The usual methods of practical calculation are explained as well as a new procedure which combines great accuracy with brevity. Merkel's method is extended to injection coolers for gas and compressed air. It is suggested that the dimensionless "evaporation coefficient" should be called "Merkel coefficient." From author's summary

987. Dusinberre, G. M., A note on latent heat in digital computer calculations, ASME-AIChE Joint Heat Transfer Conf., Chicago, Ill., Aug. 1958. Pap. 58-HT-7, 3 pp.

In the calculation of transient temperature in solids, certain difficulties arise when there is a phase change involving a latent heat or high instantaneous values of specific heat. Such changes occur in melting or freezing or at transition points in metals, notably steel. This paper outlines methods of calculation which are specially adaptable for digital computers.

From author's summary

988. Dunn, R. J., and Stuhlbarg, D., The pressure drop of condensing steam in horizontal pipes, ASME-AIChE Joint Heat Transfer Conf., Chicago, Ill., Aug. 1958. Pap. 58-HT-2, 4 pp.

989. Khomenko, V. S., The transition of a single-phase system into a two-phase system under the influence of a heat source, *Soviet Phys.-Tech. Phys.* **2,** 7, 1418–1423, June 1958. [Translation from *Zh. Tekh. Fiz., Akad. Nauk SSSR* **27,** 7, 1534–1539, July 1957 by Amer. Inst. Phys., Inc., New York, N. Y.]

Problem considered is the transition of a homogeneous single-phase medium into a two-phase medium by the action of a time-varying heat source. Two-dimensional, cylindrically symmetric, and spherically symmetric cases are analyzed. The coordinate of the interface is assumed to vary as the square root of time, and this determines how the heat source varies. Resulting partial differential equation with coordinate and time as independent variables, and temperature as dependent variable, is solved analytically.

D. Chapman, USA

990. Hahnemann, H. W., Conduction and transfer for liquid drop films (in German), *ZVDI* **100,** 2, 60–61, Jan. 1958.

991. Burov, Yu. G., Heat exchange during water vapor condensation in vertical tubes (in Russian), *Zh. Tekh. Fiz.* **27,** 2, 331–337, Feb. 1957.

The experimentally determined heat-transfer coefficients are reported to exceed by 10% those computed from Nusselt's equation for film condensation with condensate Reynolds numbers ranging up to 800. Experiments show also that dropwise condensation on the upper portion and film condensation on the lower portion of the tube can occur simultaneously and can be maintained over long periods of time. When this occurs the material and the condition of the surface have a great effect on the heat-transfer coefficient. According to the author this could account for the discrepancy of experimental data reported by various researchers.

N. Zuber, USA

992. Labuntsov, D. A., Effect of the temperature dependence of the physical characteristics of condensate on heat transfer during vapor film condensation (in Russian), *Teploenergetika* **4,** 2, 49–51, Feb. 1957.

993. Baum, V. A., and Brdlik, P. M., Condensation of steam from a moving steam-air mixture (in Russian), *Teploenergetika* **4,** 1, 42–45, Jan. 1957.

Experimentally determined condensation rates for steam condensing from an air-steam mixture flowing inside vertical tubes are reported. Data were taken at atmospheric pressure; the Reynolds number of the mixture was varied between 1300 and 40,000, and the steam content from 3% to 95% by volume. An equation which correlates the data with a ±6% deviation is derived using dimensional analysis.

N. Zuber, USA

994. Burov, Yu. G., Heat exchange with steam condensation on vertical tubes (in Russian), *Soviet Phys.-Tech. Phys.* **2,** 2, 297–302, Feb. 1957. [Translation of *Zh. tekh. Fiz., Akad. Nauk SSSR* **27,** 2, 331–337, by Amer. Inst. Phys., Inc., New York, N. Y.]

Paper reports heat-transfer data for steam condensing at 1.02 atm on the outside of vertical 20-mm diameter copper tubes of length 1000, 550 and 275 mm. Ports permitted visual inspection of the condensation at the top part of the tubes.

When no dropwise condensation was observed at the top, the test data were generally around 10% higher than that predicted by the Nusselt equation suggested by most heat-transfer texts. Many tests had mixed dropwise and film condensation, in which case the test data varied in amounts greater than 10% above the Nusselt prediction.

W. M. Rohsenow, USA

995. Fuks, S. N., Heat transfer during the condensation of moving steam in a horizontal bundle of tubes (in Russian), *Teploenergetika* **4,** 1, 35–38, Jan. 1957.

Experimentally determined heat-transfer coefficients for condensing steam flowing across a bundle of 72 horizontal brass tubes are reported. Data were taken in the pressure range 0.047 to 1.052 atm, and at Reynolds numbers 800 to 6000. An equation which correlates the data with a ±10% deviation is presented also.

N. Zuber, USA

996. Labuntsov, D. A., Effect of convective heat transfer and the forces of inertia on heat exchange during laminar flow of condensate film (in Russian), *Teploenergetika* **3,** 12, 47–50, Dec. 1956.

997. Shubin, E. P., A new approximate formula for mean logarithmic temperature differences (in Russian), *Teploenergetika* **4,** 2, 40–41, Jan. 1957.

998. Wegener Sleeswijk, A., On the optimum conditions in an isenthalpic liquefaction process, *Appl. Sci. Res. (A)* **7,** 1, 29–36, 1958.

Two criteria for optimum conditions in isenthalpic liquefaction processes are discussed. The first criterion treated is that of maximum yield of liquid per unit of gas compressed. This well-known criterion leads to conditions corresponding to the inversion curve. The second criterion discussed is that of maximum yield per unit of energy expended. This criterion is evaluated and it is shown that it leads not only to greater efficiency but also to working pressures that are considerably lower than those deduced from the first criterion. It should be noted, however, that often in engineering practice neither of the two criteria is applicable because of technical or economical limitations set to the working pressure.

From author's summary

999. Gusev, I. V., Nikitina, N. I., and Aerov, M. E., Heat and mass transfer in a granular layer (in Russian), *Zh. Tekh. Fiz.* **26,** 9, 2005–2007, Sept. 1956.

1000. Mel'nikov, V. I., The motion of a fluid in a mixer (in Russian), Investigations of sublimation and distillation apparatus and of the hydrodynamics of mixers (Vses. n.-i. i konstruktorn in-ta khim. mashinostr., sb. st. 16) Moscow, 1954, 105–120; *Ref. Zh. Mekh.* no. 4, 1957, Rev. 4220.

Combustion

(See also Rev. 1058)

1001. Wolfhard, H. G., and Burgess, D. S., The ignition of combustible gases by flames, *Combustion and Flame* **2,** 1, 3–12, Mar. 1958.

Tests were made to determine ignition conditions with change of pilot fuel, oxidant and inert gas, thus varying energy content of pilot. Because of very small ignition energies associated with ignition of hydrocarbon-air mixtures, stoichiometric methane-nitric

oxide mixtures were used, permitting conveniently large pilot flames without ignition. Authors' summary states in part: "For very small pilot flames the condition for ignition is a minimum energy flow (cal/s), whereas for large pilots a minimum temperature is necessary. This minimum ignition temperature is little related to the spontaneous ignition temperature. Ignition does not occur close to the burning zone of the pilot, but at the end of a luminous reacting column in which reaction rates, diffusion processes and heat conduction are the determining processes."

Minimum ignition energy for instantaneous ignition is about 10 millijoules which, related to minimum energy flow for continuous ignition of 10 joule/sec, gives time factor of 10^{-3} sec. Authors hope to report on hydrocarbon ignition in future. Correlation of these data with hydrocarbon gases, liquid and solid fuels in air suspension will greatly increase value of this report.

D. Aronson, USA

1002. Selberg, H. L., and Johansson, C. H., Numerical calculation of the temperature rise in ignition by hot wires (in English), *Ark. Fysik* **13**, 5, 423–427, 1958.

Article gives the results of a numerical calculation of the temperature development in the explosive medium around a wire, the temperature of which is suddenly raised by applying a certain amount of energy. The explosive medium is assumed to decompose according to the Arrhenius law when the explosive heat is released.

H. Faught, USA

1003. Carpenter, D. L., and Davies, D. R., The variation with temperature of the explosibility characteristics of coal dust clouds, using electric spark ignition, *Combustion and Flame* **2**, 1, 35–54, Mar. 1958.

Measurement of ignition energy required for coal dust in air and in oxygen-depleted and oxygen-enriched mixtures indicated that required spark energy decreased with increasing temperature to some limiting temperature, then increased with increasing temperature, finally exceeding energy input limits of apparatus so that ignition could not be effected. Upper temperature limit of ignitability increases with increasing oxygen content of oxygen-nitrogen mixture in which coal dust is suspended. Minimum energy level for ignition occurs in temperature range 200 C to 300 C. Upper limit of ignitability varies from 300 C to 450 C with increasing oxygen content from 17% to 28%, and with increasing coal volatility. Effect is attributed to depletion of oxygen molecules with increasing temperature associated both with decreased gas density and reaction of oxygen with coal prior to ignition.

Study was initiated because of concern about explosion hazard associated with "fluidization process wherein the caking and swelling tendencies of certain coals are reduced by mild oxidation .... under suitable conditions an electrostatic discharge could be created in a coal dust cloud." Authors do not see how test results can be applied directly and meaningfully to the problem which spurred the study, but qualitative guidance is afforded.

D. Aronson, USA

1004. Gerstein, M., and Potter, A. E., Jr., Considerations related to the quenching of flames with simple kinetics, Heat Transf. and Fluid Mech. Inst., Univ. of Calif., Berkeley, Calif., June 1958, 69–79.

Quenching distances are for the hydrogen-bromine flame and the hydrazine and ozone decomposition flames on the basis of previously reported kinetic expressions. The calculated values are compared with meager, not very concordant, experimental data.

M. A. Mayers, USA

1005. Mayer, E., A theory of flame propagation limits due to heat loss, *Combustion and Flame* **1**, 4, 438–452, Dec. 1957.

In spite of the importance of flammability limits they are not predicted by theoretical treatments of the steady-state combustion wave. In this attempt to explain composition limits the effect of heat loss from the flame front upon the steady-state propagation of a one-dimensional combustion wave is treated. The temperature of the flame governs the chemical reaction rates producing heat according to an exponential Arrhenius-type law. When the flame temperature is reduced by heat losses, convective and radiative, the heat-producing chemical reaction rates will diminish more rapidly than corresponding heat loss rates. The energy balance between the rate of heat generation and loss is employed to deduce limiting flame propagation conditions. Within the uncertainties in information needed to make the calculation, the theoretical results are in agreement with observed data for hydrogen-air and propane-air mixtures.

H. F. Calcote, USA

1006. Filippi, F., Flame stabilization in air-breathing jet (in Italian), *Aerotecnica* **38**, 1, 19–38, Feb. 1958.

The problem of flame stabilization in the combustion chambers of air-breathing jet engines is considered from a general viewpoint and separately from the other combustion problems. The experimental results are reviewed and discussed in part I. Most of them have been obtained with bluff body stabilizers in homogeneous gas streams. The discrepancies between the different authors are of more than small significance, and there seems to be no generally agreed mechanism of flame stabilization. None of the many proposed theories seems to fit the experimental data in full or to give figures which can be used in practical combustion systems.

Very little has been published on the subject of flame stabilization in fuel sprays and on can-type stabilizers, in spite of their wide use in engines. Interesting results have been obtained with gas jets acting as stabilizers and this type should find a wide application in the future since its characteristics are the most promising.

In part II the application of the previously examined stabilizers to the combustion systems of turbojets, ramjets and afterburners is briefly discussed. The lines of possible development and future research are outlined and the need for a fundamental approach to the problem is demonstrated.

From author's summary

1007. Weiss, M. A., Lang, R. J., and Longwell, J. P., Combustion rates in spherical reactors, *Indust. Engng. Chem.* **50**, 2, 257–264, Feb. 1958.

Combustion is carried out in a well-stirred spherical reactor. The authors postulate a simplified mechanism for the combustion of iso-octane, and blowout studies are conducted to measure the pseudo-kinetics constants relevant to this postulated mechanism. The primary independent variables are inlet feed gas temperature, air-hydrocarbon ratio, and ambient pressure. A pseudo-activation energy of approximately 42 kcal/gm mole was previously evaluated by varying air-hydrocarbon ratio at a gas feed temperature of 400 K. This is in good agreement with the newly estimated value for pseudo-activation energy, 42–48 kcal/gm mole based on data at a feed gas temperature of 866 K.

In addition to the work on iso-octane, results of similar combustion experiments with the following compounds are reported: heptane, methane, dicyclopentadiene, 5% *n*-propyl nitrate in iso-octane, benzene, toluene, xylene, tetralin, isopropyl chloride, propylene oxide, and hydrogen. The kinetics data for these compounds are adjusted for comparison with the iso-octane data by correcting for differences in the heats of combustion. It is shown that this correction is insufficient to account for the observed differences in combustion rates. It is thus concluded that molecular structure, in addition to thermal effects, is influential on high temperature combustion rates. These differences are not necessarily associated with relatively low temperature combustion phenomena such as octane number, thermal fragmentation and ignition delay.

M. Baker, USA

1008. Lucquin, M., Contribution to the study of combustion of saturated hydrocarbons at low temperatures. I and II (in French), *Rev. Inst. Fr. Petrole et Ann. Comb. Liq.* **12**, 10, 1079–1119, Oct. 1957; **12**, 11, 1168–1197, Nov. 1957.

Saturated or unsaturated open-chain hydrocarbonaceous compounds, placed in oxygen at a temperature of 200 to 500 C, undergo two different inflammations, the morphology of which is fairly complicated. The determination of this morphology and study of the factors apt to modify it give interesting information on the chemical mechanism of oxidation.

Pentane has been studied more particularly because of the ease with which it can be used for experiments.

From author's summary

1009. Chu, S. T., An iterative method of determining equilibrium compositions of reacting gases, *Jet Propulsion* **28**, 4, 252–254, Apr. 1958.

Usual material balance and equilibrium equations are solved. Method provides explicit correction terms for each succeeding iteration. Efficiency of iteration is expected to be independent of mixture ratio. Author claims that convergence should be rapid and that first- or second-order approximations will provide accurate results in most cases. M. Gerstein, USA

1010. Karasharly, K. A., Kerimov, G., Nasirov, Ya. N., Rozlovskii, A. I., and Shaulov, Yu. Kh., The conditions governing the appearance of instability in normal combustion (in Russian), *Dokladi Akad. Nauk AzSSR* **11**, 12, 819–823, 1955; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5293.

An experimental study of the propagation of a flame in mixtures of methane-oxygen and acetylene-oxygen with the object of evaluating the lower range of Reynolds numbers, corresponding to the transition limit of normal combustion to detonation. The experiments were carried out in transparent rubber casings, with a volume of up to 20 liters. In the combustion of mixtures of methane and oxygen, detonation was not studied; the commencement of the acceleration of the flame corresponded to Reynolds numbers of the order 0.4×10^4. B. V. Raushenbakh

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

1011. Tanasawa, Y., and Tamura, Z., On the theory of combustion of a single fuel droplet, taking into consideration the variation of the physical properties of the surrounding gas with temperature (in Japanese), *Science of Machines* **9**, 6, 671–677, 1957.

Assuming that the thermal properties of the surrounding gas, i.e., the thermal conductivity, the coefficient of diffusion, and the specific heat, are linear functions of the temperature, authors obtained expressions for the temperature distribution, and for the fuel vapor concentration around a single drop during combustion. The effects of the surrounding pressure on the coefficient of combustion velocity are also discussed. The expressions are developed step by step, and numerical examples are worked out, the results of which are shown in charts.

K. J. DeJuhasz, Germany

1012. Miesse, C. C., A theory of spray combustion, *Industr. Engng. Chem.* **50**, 9, 1303–1304, Sept. 1958.

Previous researches on the effect of atomization on the performance of liquid propellant combustors established the beneficial effects of finer atomization and detrimental effects of viscosity. The intermediate processes of evaporation and chemical conversion were also investigated, and some dimensionless groups were established for correlating the experimental data. The present theory is based on the assumptions that (1) the propellants react only in the vapor phase as a single chemical substance, (2) the system is isothermal, (3) the propellant vapors mix immediately upon formation. The rate of propellant conversion is expressed as a function of reaction rate and the amount of the remaining unreacted propellant, and brought into relationship with the average axial velocity, the penetration distance of the droplets and the length of vapor section.

The resulting equations give some design data for the combustor with given performance requirements. Charts are given for performance as a function of length of vapor section for various atomization parameters; also for variation of performance with drop size, for various chamber lengths. A typical numerical example is worked out. K. J. DeJuhasz, Germany

1013. Tanasawa, Y., and Tesima, T., On the theory of combustion rate of liquid fuel spray, *Bull. JSME* **1**, 1, 36–41, 1958.

The rate of combustion of a single fuel drop depends on the size of the drop. A spray comprises a large number of drops of various sizes. The rate of combustion of a fuel spray in a diesel engine or gas turbine is difficult to determine because of the variety of drop sizes and their distribution. Authors propose a simplified theory and derive, partly by mathematical and partly by graphical methods, a formula giving the unburned amount at a given instant after the beginning of combustion. Charts are shown for change of weight distribution during combustion for various initial size distribution of droplets in the spray. The results apply only to an initial distribution according to the Rosen-Rammler formula, therefore the authors' formulas correspond not strictly to actuality, but serve mainly as a standard for comparison. Reference is made to the prior work of Brobert 1946, Tanasawa 1954, and Nukiyama and Tanasawa 1940. K. J. DeJuhasz, Germany

1014. Agafanova, F. A., Gurevich, M. A., and Paleev, I. I., Theory of burning of a liquid fuel drop, *Soviet Phys.-J. Tech. Phys.* **2**, 8, 1689–1695. [Translation of *Zh. Tekhn. Fiz., Akad. Nauk SSSR* **27**, 8, 1818–1825, Aug. 1957, by Amer. Inst. Phys., Inc., New York, N. Y.]

Some researchers have obtained many results by using the well-known diffusion theory concerning the burning of a liquid fuel drop. But this theory has difficulties in some points, such as the analysis of the unsteady burning process and the disagreement with experimental results on the radius of the burning zone. In this paper these difficulties are eliminated by taking account of the finite chemical reaction rate, namely, by assuming that the oxidation rate of the fuel vapors is not infinite but follows the Arrhenius law and the reaction is bimolecular.

A nondimensional equation of the temperature distribution in a combustion layer is derived with a set of simplifying assumptions. On the basis of this equation, the value of the maximum temperature is lower and its zone closer to the liquid surface than those derived from the diffusion theory. These results are in qualitative agreement with experiment. Further calculation makes it possible to analyze the ignition and extinction condition and the yield of the unburned vapors of liquid fuel. H. Jinno, Japan

1015. Nash, P., and Rasbash, D. J., The use of water in fire fighting, *Proc. Instn. Fire Engrs.* 24 pp. + 14 figs. + 8 refs. + discussion, 1955.

Fire-fighting methods and materials can be compared by measuring the time taken to control and extinguish a fire when the fire-fighting material is applied at different rates. Below a certain rate the fire cannot be extinguished, i.e., the time to extinguish becomes very large. At rates above this "critical" the time needed to extinguish falls off rapidly. Similar relation holds good for the amount of water used versus the rate of flow. Effect of ventilation and of a moving jet or spray on the amount of water used can be expressed in curves. Data are given on extinguishing fully developed fires in furnished rooms of 1500-cu. ft. volume by water jets and sprays applied at various rates and pressures. Comparison is made also as regards the volume of steam developed

in the process, by calculating the heat required to turn the water into steam. Effect of drop size of water is tabulated, on fires of various liquid hydrocarbon fires. Use of water as foam is discussed. Authors conclude that the quickest "knock-down," i.e. application of water at the highest possible rates, is best.

K. J. DeJuhasz, Germany

1016. Nash, P., Some new techniques in fighting fires, *Fire, London* **48,** 541–542, Apr. 1956.

New methods developed recently in applying new and traditional fire-fighting materials are discussed. The "critical rate," i.e., the rate of water delivery below which it does not extinguish a "standard" fire, was used as basis of comparison. Author investigates whether water jets or water sprays are more effective, and whether there are advantages in increasing the water pressure above the presently used 100 psi; some American equipment is capable of delivering at rate of 2500 gal/min at a distance of 300 ft. Use of foam against liquid fires, both by above the surface and by "base-injection" method, especially in gasoline storage tanks, is receiving attention. Base injection of foam is effective only under definite conditions, which are being studied with detailed researches. Fighting crash fires of aircraft presents the most difficult, but also the most important, problems; a combination of a "knocking-down" agent, such as dry powder or a vaporizing liquid, and a foam as "sealing agent" is being investigated.

K. J. DeJuhasz, Germany

Prime Movers and Propulsion Devices

(See also Revs. 629, 979, 1006, 1057, 1067, 1095)

1017. Reinhart, A. A., Successive approximation method for quick solution concerning charging of two-cycle diesel engines (in German), *Motortech. Z.* **19,** 1, 2–9, Jan. 1958.

The proper matching of turbocharger and two-stroke diesel engine is a rather complex problem and it requires a large amount of calculating work. The study shows how the solution of this problem can be approached by means of three nomograms, which are based on relations derived from the energy and flow balances of air compressor, two-stroke diesel engine and exhaust gas turbine. From author's summary

1018. Berchtold, M., and Gardiner, F. J., The Comprex . . . a new concept of diesel supercharging, ASME Gas Turbine Power Conf., Washington, D. C., Mar. 1958. Pap. 58-GTP-16, 12 pp.

The Comprex supercharger compresses air by direct transmission of energy from an expanding gas utilizing compression and expansion waves. The name Comprex is a contraction of Compression-Expander. Although the phenomena of nonsteady flow have been studied extensively in connection with explosions, diesel fuel injection, railway airbrakes, water hammer, safety equipment in hydraulic power stations, and so on, the use of these effects in gases is relatively new. This paper deals with the Comprex as applied to supercharging of internal-combustion engines. It explains the principle of operation, describes the design and discusses the particular operational characteristics as a supercharger for a 4-cycle diesel engine. It should be remembered that this is only one of many applications of a broad and unexploited field. From authors' summary

1019. Massey, A. G., and Oldenburger, R., Scientific design of a diesel governor, ASME Oil and Gas Power Conf., Philadelphia, Pa., May 1958. Pap. 58-OGP-11, 11 pp.

Paper describes procedure followed in designing a governor for a specific diesel application, where the characteristics of the engine and load are known. The simplifying assumptions that are made in setting up the over-all system equations are described. The effect of varying certain system parameters on the over-all performance is considered and the authors state some general principles that are applicable to similar type governors.

S. Z. Dushkes, USA

1020. Burri, H. U., Nonsteady aerodynamics of the Comprex supercharger, ASME Gas Turbine Power Conf., Washington, D. C., Mar. 1958. Pap. 58-GTP-15, 8 pp.

A brief outline is given of the method of characteristics for the analysis of one-dimensional nonsteady flow. Two typical types of experiments are discussed which indicate the degree of accuracy possible if this method is applied to machinery like the Comprex supercharger. As an example, a typical analysis is presented for one particular engine-performance point. It is possible to duplicate engine test results with acceptable accuracy.

From author's summary

1021. Moiroux, A. F., The free-piston-engine possibilities, ASME Oil and Gas Power Conf., Philadelphia, Pa., May 1958. Pap. 58-OGP-7, 13 pp.

1022. Hasen, M. M., Flow volumes and pressures in steam and gas turbines working at other than rated conditions (in Russian), *Trudi Mosk. transp.-ekon. in-ta* no. 3, 167–176, 1956; *Ref. Zh. Mekh.* no. 3, 1957, Rev. 2957.

The working conditions are examined of a group of reaction turbine stages at other than rated output, with subcritical outflow velocities.

From the continuity equation and assuming constant velocity coefficient, author derives an expression for determining the flow of steam through the turbine. The equation obtained is somewhat different from the analogous Flügel formula. Comparison of experimental data with the results of the calculation shows that the error in calculation increases for outputs differing greatly from the rated value, reaching 4–5%. L. I. Kiselev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1023. Lokai, V. I., The influence of radial clearance on the heat process in a gas-turbine stage with long blades (in Russian), *Trudi Kazan. aviats. in-ta* **27,** 70–90, 1953; *Ref. Zh. Mekh.* no. 3, 1957, Rev. 2954.

The method of calculation is described of the gas loss through the radial clearance of a gas turbine stage with blade twist. Applying the Bernouilli equation, into which the coefficients of velocity loss in the guide ring and the rotor blades are introduced, it is assumed that the gas in the radial clearance expands only axially. The results are given of a numerical calculation of the influence on the relative internal efficiency of the turbine stage of variation of the magnitude of the radial clearance from the calculated value. The calculations show that with increase of the relative clearance by 1% over the calculated value, the efficiency falls by about 1–2%. A. G. Ivanishchev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1024. Masslov, L. A., A rational method for calculating the blading sections of gas turbines under rated and intermediate working conditions (in Russian), *Trudi Vses. nauch. inzh.-tekhn. o-va sudostroyeniya* **6,** 3, 13–32, 1955; *Ref. Zh. Mekh.* no. 3, 1957, Rev. 2950.

A method is suggested for selecting the fundamental parameters in the design of marine gas turbine installations for rated and intermediate powers, founded on the use of unidimensional equations for the flow through the individual elements of the blading. The

coefficients required for performing the method are to be obtained from a specially arranged experiment.

N. A. Kolokol'tsov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1025. Beck, L., The control of gas turbines in jet-powered aircraft (in German), *Z. Flugwiss.* **5,** 7, 198–204, July 1957.

An outline is given of the fundamental laws for the control of gas turbines in jet-powered aircraft. Included in the discussion are gas turbines with and without afterburners as well as with and without adjustable jet nozzles. The discussion includes the jet with sonic velocity. The effect of the flight condition (due to accumulated gas temperature and accumulated total pressure in the intake) on the working conditions of the engine is set apart from the actual engine characteristics with relevant parameters. Thus the fundamental laws for the control are especially clear, and the possibility emerges of considering the fundamental laws for the simple control of a stationary plant as a special case.

From author's summary

1026. Formentini, P., The indication of the specific fuel consumption of turbojets (in Italian), *Aerotecnica* **38,** 1, 39–43, Feb. 1958.

Attention is called to the circumstance that the indication of the specific fuel consumption of turbojets, in lbs/hr per lb of thrust, does not satisfy the traditional concept of mechanics, i.e. to indicate a specific consumption as a ratio between an expended consumption per hour and an obtained work per hour. Author suggests referring the consumption per hour of turbojets not to the force "thrust," but to a well-defined power of the machine, preferably independent of the flight speed. According to the author, the power most suited to this aim is the static power, and its advantages are illustrated. From author's summary

1027. Dietz, R. O., Jr., and Hinners, A. H., Jr., Ramjet test facility planning, *Jet Propulsion* **28,** 5, 315–320, May 1958.

1028. Sears, G. A., and Bajek, J. J., Testing air-breathing supersonic powerplants, *Jet Propulsion* **28,** 5, 303–307, May 1958.

1029. Wooten, F. O., An experimental study of an aerodynamic rectifier, WADC TR 57-356 (ASTIA AD 130779), 31 pp., June 2957.

Experiments on an aerodynamic rectifier (device with no moving parts for permitting flow in one direction only) are described. In the restricted flow direction the flow is constrained to move in a helical path by airfoils in cylindrical cascade. For steady-state conditions the mass flow in one direction was ten times that in other. However, one suggested application is as a valve in a pulse-jet engine and for this purpose the performance in pulsating flow is significant. It was found that the starting time for the flow to reach a steady state after the application of a pressure pulse was about 14 milliseconds, or about four times the period required for the passage of a sound wave through the rectifier.

C. Scruton, England

1030. Rosenblum, L., Small power plants for use in space, *Aero/Space Engng.* **17,** 7, 30–33, July 1958.

Article considers power plants utilizing three energy sources—chemical, solar, and nuclear—capable of an electric power output in the range of 100 to 1000 watts.

From author's summary

Magneto-fluid-dynamics

1031. Rosen, P., Variational approach to magneto-fluid-dynamics, *Phys. Fluids* **1,** 3, p. 251, May–June 1958.

Author has previously shown [*J. Chem. Phys.* **21,** p. 1220, 1953] that the Rayleigh-Onsager principle of least dissipation of energy [*Phys. Rev.* **37,** p. 405, 1931] can be used to obtain a variational principle for the flow of a viscous incompressible fluid. Adding Joule losses to the viscous dissipation and suitably modifying the energy balance statement, he now arrives at a more general variational principle applying to the motion of a viscous adiabatic fluid with finite electrical conductivity. Displacement currents are omitted, as is consistent with the nonrelativistic character of the analysis. J. W. Butler, USA

1032. Resler, E. L. Jr., and Sears, W. R., The prospects for magneto-aerodynamics, *J. Aero Sci.* **25,** 4, 235–245, Apr. 1958.

Paper discusses the equations of motion of conducting fluid in a magnetic and an electric field. It also presents the order of magnitude of the conductivity likely to arise in aerodynamic problems and the resulting range of magnetic Reynolds numbers which are seen to be small. It then presents some simple solutions, including channel flow for liquids and gases. The latter leads to interesting new results on the effect of fields or choking.

L. Trilling, USA

1033. Rossow, V. J., Magneto-fluid-dynamics analysis of heat transfer near a stagnation point *J. Aero. Sci.* **25,** 5, 334–335 (Readers' Forum), May 1958.

Author calculates the reduction in heat transfer at a two-dimensional stagnation point in an incompressible, constant property fluid due to a magnetic field alined with the free-stream direction. The work is an extension of the analysis reported in NACA TN 3971, 1957, wherein the effect of a magnetic field on the skin friction was studied. The secondary magnetic field induced by the motion of the fluid through the primary field is neglected throughout. Joule heating and viscous dissipation terms are carried in the energy equation. Computing machine solutions show that 16% reductions in heat transfer at the stagnation point and in its vicinity accrue with moderate field strength and conductivities.

H. A. Stine, USA

1034. Neuringer, J. L., and McIlroy, W., Hydromagnetic effects on stagnation-point heat transfer, *J. Aero. Sci.* **25,** 5, 332–334 (Readers' Forum), May 1958.

Authors calculate the reduction in heat transfer at a two-dimensional stagnation point in an incompressible, constant property fluid due to a magnetic field aligned with the free-stream direction. The work is an extension of the analysis reported in *J. Aero. Sci.* **25,** 3, 194–198, Mar. 1958, wherein the reduction of the skin friction due to the magnetic field was evaluated. In the latter analysis the change in the imposed magnetic field induced by the electric currents in the fluid is fully taken into account. However, in the heat-transfer solution, the effect of the magnetic field is introduced only insofar as it influences the flow velocity components, the effects of Joule heating and viscous dissipation being neglected as small. Results of machine computations show that the stagnation point heat transfer can be reduced by as much as 28% by a magnetic field of reasonable strength in a fluid of relatively small electric conductivity.

The same problem has been solved by Rossow [see preceding review this issue] in a slightly different way. In Rossow's solution the change in the imposed magnetic field induced by the electric current is neglected in the momentum equations, but the Joule heating and viscous dissipation terms are retained in the energy equation. The numerical results of the two analyses are the same for practical purposes. H. A. Stine, USA

1035. Bond, J. W., Jr., Plasma physics and hypersonic flight, *Jet Propulsion* **28,** 4, 228–235, Apr. 1958.

A clear review of the problems encountered at Mach numbers greater than 12 to 15. Dissociation and ionization are evaluated. Shock-front structure and boundary-layer structure are discussed

as well as the conditions in which the different components of an ionized gas may be found. R. Betchov, USA

1036. Frieman, E. A., and Kulsrud, R. M., Problems in hydromagnetics, Advances in Appl. Mech. (edited by Dryden, H. L., and von Karman, Th.), Vol. 5, New York, Academic Press, 1958, 195–231.

Authors give survey of selected topics of continuum hydromagnetics. Review is divided in three sections. The first and shortest treats motion of magnetic lines, an energy conservation theorem, and general question of hydromagnetic equilibrium. Second part, by far the best, is completely devoted to hydromagnetic stability. Authors derive criteria for stability by normal mode and energy methods. Few examples are given. In the third part hydromagnetic waves are discussed at length. Study is confined to infinitesimal amplitudes. Authors derive properties for reflection, refraction, and transmission of such waves.

O. K. Mawardi, USA

1037. Gusa, V., and Tsigelka, I., Measurement of the temperature of a high pressure electric arc in a pneumatic switch by a method based on the plugging of the nozzle, *Soviet Phys.-Tech. Phys.* **2,** 5, 880–886, Feb. 1958. [Translation of *Zh. Tekh. Fiz., Akad. Nauk SSSR* **27,** 5, 962–969, May 1957 by Amer. Inst. Phys., Inc., New York, N. Y.]

A mathematical investigation is made of the temperature which would occur in an arc that fills a cylindrical nozzle. The basic assumptions for the calculations are Saha's equation to relate the fraction of ionized nitrogen to the temperature of the arc, and Steenbeck's principle of minimum electric field in the plasma as expanded and clarified by Th. Peters. In applying Saha's equation, author employs the energy step for the ionization potential of nitrogen but neglects the energy steps for the dissociation of N_2, the formation of possible molecular ions and all metastable states. In applying the Steenbeck principle which was derived for ambipolar diffusion into a gas, he replaces this gas with a metal surface. With these questionable assumptions, author's conclusions are still interesting, although probably most unreliable.

F. C. Todd, USA

Aeroelasticity

(See also Revs. 906, 933)

Book—1038. Abramson, H. N., An introduction to the dynamics of airplanes, 1st ed., New York, Ronald Press Co., 1958, viii + 225 pp. $4.50.

Text is provided for a senior-level course for aeronautical engineering students or for the nonspecialist in title field. First third of book presents elementary vibration and matrix theory as additional background material in dynamics. Then flutter theory and static aeroelastic phenomena are discussed. The problem of impulsive loading as encountered, for example, in aircraft landings and gust loadings is treated next. Finally, aircraft stability and miscellaneous topics in dynamics are presented. References to more advanced treatments and problems are given. Text appears admirably suited for cited course. P. A. Libby, USA

1039. Fralich, R. W., and Hedgepeth, J. M., Flutter analysis of rectangular wings of very low aspect ratio, *NACA TN* 4245, 21 pp. + 5 figs., June 1958.

The flutter characteristics of simple rectangular wings of low aspect ratio are considered on the basis of slender-wing theory. In the analysis the bending mode of distortion is assumed to be parabolic, while the chordwise mode is not prescribed. Approximate calculations of flutter boundaries when chordwise distortion is assumed to be either parabolic or cubic are compared with "exact" calculations. It is shown that, for ratios of chord to semispan less than 3, the cubic approximation gives reliable results. For higher ratios higher-order approximations to the chordwise mode of deformation must be used.

W. P. Jones, England

1040. Guyett, P. R., Supersonic wind-tunnel flutter tests of two rectangular wings, *Aero. Res. Counc. Lond. Rep. Mem.* 3080, 7 pp. + 3 tables + 10 figs., 1958.

Two rectangular wings of aspect ratio 4 were flutter-tested in supersonic wind tunnel at Mach numbers 1.6 and 2.0, using a technique in which a structural stiffness was varied to give flutter at the Mach number. The results are in reasonable agreement with calculations using theoretical three-dimensional derivatives and arbitrary wing modes, though in general the calculated critical stiffnesses are rather higher than the test values. It is shown theoretically that structural damping has an important effect upon the stiffness required to avoid flutter, and may in some circumstances be destabilizing. From author's summary

1041. Coleman, T. L., Murrow, H. N., and Press, H., Some structural response characteristics of a large flexible swept-wing airplane in rough air, *J. Aero/Space Sci.* **25,** 8, 515–521, Aug. 1958.

Paper presents an analysis of test measurements of airplane motion and strain responses for a large swept-wing airplane in flight through rough air. Power spectral methods are employed in order to provide an indication of the frequency composition of the various responses and, in this way, to determine the contribution of the various airplane rigid-body and elastic-body modes to the strain responses. The airplane rigid-body motions (pitch and vertical velocity) and elastic-body motions (deflections and twists) are examined in detail in order to assess the magnitude of the aerodynamic forces arising from these motions.

From authors' summary

1042. Fedyaevskii, K. K., and Blyumina, L. Kh., The turbulent wake of a thick wing of finite length effecting angular harmonic oscillations with large amplitudes (in Russian), *Zh. Tekh. Fiz.* **26,** 3, 618–622, 1956; *Ref. Zh. Mekh.* no. 4, 1957, Rev. 4025.

An analysis is given of the results of experiments made by V. V. Yakovenko in the Leningrad M. I. Kalinin Institute with an oscillating wing of length $\lambda = 1.335$ and provided with end disks. The wing had a rectangular design in the plan with a symmetrical Joukowsky profile of 20% thickness, and the amplitude of the rotational oscillations of the wing was equal to 10°, the axis of rotation being located at a distance equal to 35% of the length of the chord from the wing tip. It is established that in the case of harmonic oscillations of the wing the lift also varied with time according to the harmonic law with the same period as the angle of attack. Therefore the relationship of the lift to the instantaneous kinematic parameters of motion is found to be linear.

Examination also is made of the turbulence arrangement of a wing effecting oscillations with large amplitudes. In the opinion of the authors, the arrangement which takes into account both the two-dimensional turbulent wake running continuously from the trailing edge of the wing and the path of the discrete turbulence running from the wing-tip in positions close to the edge should be considered the most correct. S. M. Belotserkovskii

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

1043. Kopzon, G. I., Vibration of a slightly raked wing-body in a gas flow (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **107,** 3, 377–380, Mar. 1956.

Kopzon begins with the equation of a vibrational motion of a wing-body combination located in a stream of gas. The equation in question was derived by W. Z. Wlasov ["Shell theory and ap-

plication in technics," 1949]. This is subject to a few transformations with some assumptions concerning the form of the solution, which is expressed in terms of Hankel functions. To find the frequency of the vibration the well-known Rayleigh-Ritz method is used. No numerical example is calculated.

M. Z. v. Krzywoblocki, USA

Aeronautics

(See also Revs. 903, 908)

1044. Ayre, R. S., and Abrams, J. I., Dynamic analysis and response of aircraft arresting systems, *Proc. Amer. Soc. Civ. Engrs.* **84,** EM 2 (*J. Engng. Mech. Div.*), Pap. no. 1580, 43 pp., Apr. 1958.

Authors present an analysis of aircraft arresting systems which are considered as two-degree-of-freedom systems involving mass of rigid aircraft and mass of the energy absorption element in the arresting engine. The differential equations for aircraft displacement and for cable elongation are solved in a stepwise manner by phase plane graphical methods.

The systems are nonlinear owing to geometrical arrangement of the cable systems, to large deflection effect, and to the characteristics of the energy dissipators. Authors include investigations of the effect of varying the frontal shape and rise time of the energy dissipation function, the initial cable tension, the mechanical advantage in the cable and sheave system at the arresting engine, the deck pendant length, and the mass of the moving parts in the arresting engine. Response spectra of maximum cable tension are presented for a wide range of operating conditions.

Authors also present good comparison between the analytical and experimental results. The latter were obtained by a 1/10-length scale model using a dry-friction strip brake as the energy absorber. T. H. H. Pian, USA

1045. Thomlinson, J., A study of the aircraft arresting-hook bounce problem, *Aero. Res. Counc. Lond. Rep. Mem.* 2980, 46 pp., 1957.

Under the assumption of a perfectly rigid arresting hook system, a kinematic analysis is made of the hook bounce problem. Experimental evidence is cited to show that hook systems have a low coefficient of restitution with existing landing decks. Author concludes that successful arresting gear contact immediately after landing requires that the hook be loaded by high damper forces and that the trail angle be kept as small as possible. (Trail angle is the angle between the hook suspension and the ground line.) Design criteria are discussed. A qualitative discussion of the dynamic behavior of the arresting cables after being depressed by the landing wheels is also given.

F. W. Niedenfuhr, USA

1046. Trevaskis, H. W., Recent advances in the design of aircraft tyres and brakes, *J. Roy. Aero. Soc.* **62,** 567, 203–211, Mar. 1958.

1047. Bert, C. W., Effect of dissolution on oleopneumatic shock-strut performance, *J. Aero. Sci.* **25,** 2, 135–136 (Readers' Forum), Feb. 1958.

1048. Lang, D. A., Some problems associated with the measurement of landing distance, *AGARD Rep.* 31, 15 pp. + 1 table + 5 figs., Feb. 1956.

1049. Howe, D., Initial aircraft weight prediction, *Coll. Aero. Cranfield Note* 77, 22 pp. + 6 figs., Dec. 1957.

Although much has recently been published concerning methods for the weight prediction of individual structural components, it is some considerable time since a review of the subject as a whole has appeared. This note attempts to remedy the situation, the scope of the work not being limited to aircraft structures but including also equipment and systems.

Various stages in the design process are considered, commencing with simple formulas suitable for use in the operations system stage, passing through the more detailed project stage, and finally recommending methods suitable for weight prediction as the design becomes established.

In some instances the suggested formulas are well known but an effort has been made to utilize the latest available information in bringing techniques up to date and where possible to fill in gaps, particularly with respect to equipment and systems.

From author's summary

1050. Mangurian, G. N., The aircraft structural factor of safety, *AGARD Rep.* 154, 13 pp. + 2 tables + 9 figs., Nov. 1957.

Author presents the case for a review of the Aircraft Structural Factor of Safety in the light of appreciable advancements in structural and aerodynamic knowledge. In certain design aspects, a reduction in the presently required ultimate factor of safety is realistic and should be considered; in other aspects, a reduction should not be considered at present.

From author's summary

Astronautics

(See also Revs. 921, 1030)

1051. Newton, R. R., Lifetimes of artifical satellites, *Jet Propulsion* **28,** 5, 331–333, May 1958.

Author investigates accuracy of two assumptions made in computing lifetimes of satellites: (1) In decay from circular orbit, orbital parameters are those of a circular orbit with slowly changing radius (verified); and (2) in decay from elliptic orbit, altitude at perigee is constant (not verified). In the case of Sputnik I the error amounts to 40%. F. V. Pohle, USA

1052. Burt, E. G. C., Satellite tracking: its methods and purpose, *Endeavor, London* **17,** 68, 216–222, Oct. 1958.

The earth satellites contain instruments for transmitting information about the conditions of outer space. Such information is more useful if the satellites can be precisely located during their circuits, and, in addition, this plotting of the paths provides valuable data about the earth. The methods used and the results obtained are discussed in this article. From author's summary

1053. Nonweiler, T. R. F., Perturbation of elliptic orbits by atmospheric contact, *J. Brit. Interplanetary Soc.* **16,** 6, 368–380, Mar.–Apr. 1958.

Author discusses orbit of a vehicle describing an approximately elliptic orbit with focus at the center of a spherical Earth. He studies perturbations from the ellipse due to contact at perigee with the tenuous outer limits of the atmosphere. Air density above perigee is assumed to vary exponentially with altitude. A numerical table is provided for a typical orbit of small eccentricity. The theoretical final descent is studied, but with disregard of final severe atmospheric drag. A. A. Bennett, USA

1054. Parkyn, D. G., Elliptic orbits in a frictional atmosphere, *Amer. J. Phys.* **26,** 7, 436–439, Oct. 1958.

The instantaneous effect of friction on an elliptic orbit is commonplace mechanics, but the long-term effect of an atmosphere of variable density introduces some features of interest. In this paper an "atmosphere" is postulated which is in agreement with the rather sparse data available and the consequences for elliptic orbits are investigated. The analysis developed is general but the numerical results deduced are, of course, dependent upon the available data, with the consequent possibility of error. The problem of the life span of a satellite is solved, the numerical values taken being those for Sputnik I. From author's summary

1055. Okhotsimskii, D. E., and Eneev, T. M., Some variation problems connected with the launching of artificial satellites of the earth, *J. Brit. Interplanetary Soc.* **16,** 5, 263–294, Jan.–Feb. 1958.

Use of simplifying assumptions (a) aerodynamic forces may be neglected and (b) exit velocity, or specific thrust, is independent of propellant consumption rate make it possible to predict optimum-pitch-control and thrust-control programs for earth-satellite rockets. Initially, gravitational field is taken to be plane-parallel. It is then easily found that, in the optimum-pitch-control program, the tangent of the pitch angle is linear with time. Optimum thrust control is developed in detail for multi-stage rockets. While results do not admit of brief summary, one can get a clear concept of the way in which a minimum weight vehicle is to be designed. For a given number of stages and for a given mass ratio (initial to final) there are definite limitations on the possibility of obtaining various combinations of height and projection velocity; these are associated also with the need for a propellant reserve. In a later section authors examine the influence of the earth's rotation and find that it does not greatly alter their initial conclusions.

This is a feasibility study, not a precision orbit calculation. While the results have been duplicated in unpublished work in USA and elsewhere, widespread publication (this paper has appeared in *Uspekhi Phys. Nauk*, **63,** suppl. 1a, 5–32, Sept. 1957 and in Proc. 8th Inter. Astronautical Congr., Barcelona 1957) will be of advantage to all engineers in the missile field. It is a first-rate illustration of the portentious results that can be achieved with an understanding of the principles of mechanics, provided one stops to think before running to the nearest high-speed digital computer.

L. E. Goodman, USA

1056. Kooy, J. M. J., On relativistic rocket mechanics (in English), *Astronaut. Acta* **4,** 1, 31–58, 1958.

In considering the possibility of interstellar space flight, author envisages speeds of the order of the velocity of light; hence, the the rocket equations of classical mechanics have to be replaced by the corresponding equations of relativity mechanics, as skillfully presented by one ot the authors of "Ballistics of the future". The equations appear to be no more complicated than in the classical presentation.

Author arrives at the conclusion that—even anticipating the development of a photon or electron rocket propulsion system—the required mass ratio would become of a prohibitive astronomical magnitude and the space ship would become destroyed by waste heat. Hence we should not cling to the rocket principle as the only means of locomotion; he points toward gravitation as a source, perhaps in converting attraction into gravitational repulsion by attacking the problem on the atomic level; so far, author remains within the realms of physics.

His further excursion into the relativistic world with its time "dilatation" is insofar objectionable, as it transgresses the scope of the main theme and refers to the hypothesis of a highly dubious character and of a purely speculative nature. But the mechanics proper part of the paper has been presented in a very appealing, acceptable and thought-provoking manner.

J. Mandelker, USA

1057. Wentink, R. S., Booster propulsion for space vehicles, *Aero/Space Engng.* **17,** 7, 40–45, 51, July 1958.

The factors which constitute an engineering/economic profile are discussed as practical considerations which may profoundly influence the design of both the vehicle and the propulsion system. From author's summary

Ballistics, Explosions

1058. Stone, M. W., A practical mathematical approach to grain design, *Jet Propulsion* **28,** 4, 236–243, Apr. 1958.

Equations are developed relating solid propellant grain geometry to the important ballistic parameters of cross-sectional loading density, sliver or tail-off fraction, progressivity ratio, initial surface and web. The equations are then solved by means of high-speed computers and the results graphed. If the loading fraction, sliver, progressivity ratio and web are given, grain designs which meet or most nearly meet given requirements can be found from the graphs. The graphs are useful in determining the effect of slight variations in design parameters. Illustrations of the use of the graphs are given for the internal-burning star and the internal-burn-wagon wheel configurations. Calculations have also been made on a modified form of the wagon wheel which permits one, two or three levels of thrust during burning.

From author's summary by M. Gerstein, USA

1059. Karavainikov, V. N., Fluctuations of amplitude and phase in a spherical wave, *Soviet Phys.-Acoustics* **3,** 2, 175–186, Feb. 1958. [Translation of *Akust. Zh., Akad. Nauk SSSR* **3,** 2, 165–176, Apr.–June 1957, by Amer. Inst. Phys., Inc., New York, N. Y.]

Author presents a mathematical analysis of the propagation of a spherical wave in a medium with an index of refraction which fluctuates slightly about unity, the fluctuations depending only on the space coordinates. A linear equation is obtained for a function related to the variation of the wave function from that found in a homogeneous medium, assuming that the variation in phase and the relative variation in amplitude must be small over a wave length. The solution of this equation is given in integral form. Integral expressions are given for the mean-squares of the amplitude and phase fluctuations and these are examined for special cases. It is shown that there is a correlation between the amplitude and phase fluctuations at a receiver a small distance from the source which decreases with increasing separation, finally vanishing. Autocorrelation functions of the phases and amplitudes at two receivers in line with the source are also given as a function of the separation of the two receivers. G. C. Wallick, USA

Acoustics

(See also Rev. 713)

Book—1060. Schuster, K., Turbulence and wave amplification (in German), *Ann. Phys.* **20,** 6, 381–385, Nov. 1957.

The onset of turbulence in a laminar flow is evaluated by author from an acoustical point of view, considering a wave motion superimposed on a two-dimensional stream between parallel plates. For sake of simplicity the wave is supposed progressive along the axis, having a frequency of the first mode only. The need to satisfy the Navier-Stokes equations and the continuity equation for adiabatic process results in a fifth-order equation having the prop-

agation constant as unknown. From the discussion of an approximate solution of this equation, taking into account proper physical constants, emerges a critical value of the Reynolds number; beyond that, an upstream propagation with increasing wave amplitude is possible. This value is of the same range as the customary transition values from laminar to turbulent flow. As author states, it remains open to question if the sketched acoustical pattern is really to be linked with the beginning of turbulence in fluids.

A. Ghetti, Italy

1061. Altenburg, K., Sound velocity in entropy-elastic media (in German), *Kolloid Z.* **155,** 2, 106–109, Dec. 1957.

The velocity of sound c depends on the intermolecular forces caused by elastic deformations and by entropy elasticity; the latter is due to entropy changes under strain. By thermodynamical reasoning, author establishes the dependence of c on the internal energy and entropy. The results are applied to ideal rubber-like substances.

F. E. Borgnis, Germany

1062. Evans, E. J., and Parkin, P. H., Sound absorption of a stone wall (in English), *Acustica* **8,** 1, 117–118, 1958.

1063. Koga, I., Aruga, M., and Yoshinaka, Y., Theory of plane elastic waves in a piezoelectric crystalline medium and determination of elastic and piezoelectric constants of quartz, *Phys. Rev.* (2) **109,** 5, 1467–1473, Mar. 1958.

Paper discusses the general theory of propagation of plane waves in a piezoelectric crystal. Previous theories have omitted the piezoelectric stress term. When this is taken into account, authors find agreement with the experimental observations of Atanasoff and Hart [*Phys. Rev.* **59,** p. 85, 1941]. The presence of the piezoelectric stress terms makes the calculation of the frequencies more complicated than the usual treatment. The results when compared with experimental measurements agree up to 200 C for X cut plates and up to 300 C for Y cut plates.

J. M. Jackson, Scotland

1064. Mikhailovskii, V. N., and Sykhan, A. I., Effect of static tension on sound conductivity and speed in metals (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 1, 139–140, Jan. 1957.

1065. Mikhailov, I. G., The absorption of ultrasonic waves in viscous liquids, *Soviet Phys.-Acoustics* **3,** 2, 187–192, Feb. 1958. [Translation of *Akust. Zh., Akad. Nauk, SSSR* **3,** 2, 177–182, Apr.–June 1957, by Amer. Inst. Phys., Inc., New York, N. Y.]

Test results on sound absorption by castor oil and other vegetable oils in the frequency range 0.26 to 30 mc are reported. Although a broad continuous spectrum of relaxation times was inferred, the experimental data were approximated by a 3-term formula incorporating relaxation times for two different relaxation processes.

W. W. Soroka, USA

1066. Naake, H. J., Tamm, K., Dammig, P., and Helberg, H. W., Formation of air bubbles in air-saturated water at reduced pressure and their indication by an acoustical measuring procedure (in English), *Acustica* **8,** 3, 142–152, 1958.

With the aid of sound-absorption measurements the formation of bubbles in water saturated with air is investigated. The bubbles occur when the static air pressure in the sample holder is reduced gradually or in steps. The formation of bubbles is reduced when the water is subjected to a pressure greater than atmospheric before commencing the experiment.

The behavior of air pockets adhering to solids and of air-filled pores in the walls of the container or in solid particles under conditions of increased or of decreased pressure is considered. Calculations of the growth and ascent of bubbles and the sound absorption caused thereby are compared with measurements.

From authors' summary

1067. Franken, P. A., Review of information on jet noise, *Noise Control* **4,** 3, 8–16, May 1958.

Author presents an excellent survey of current information on the noise field produced by a jet engine. He sets forth engineering procedures for the evaluation of sound pressure levels in this field. He concludes with a discussion of various noise suppressors, their principles of operation, and the practical limits of noise reduction by these means.

M. C. Junger, USA

Micromeritics

(See also Revs. 836, 845, 1011, 1012, 1013, 1014, 1097)

1068. Artemyeff, P. P., The motion of material in a high-speed elevator bucket and the determination of the filling ratio of the bucket (in Russian), *Trudi Leningr. in-ta inzh. vod. transp.* no. 23, 228–240, 1956; *Ref. Zh. Mekh.* no. 3, 1957.

An approximate solution is presented for the two-dimensional problem of the motion of a pulverulent material in the bucket of a high-speed elevator at the instant of emptying (tipping) of the bucket. The solution is founded on the following assumptions: (1) The slip lines of the material within the limits of the bucket are rectilinear; (2) The slip lines are constant during the motion of the bucket around the upper drum.

A differential equation of motion of an elementary volume of the pulverulent material is set up, whose solution determines the velocity field and the displacements of the material particles in function of the coordinates and the time. From an analysis of the solution, a method is developed for determining the coefficient of filling of the bucket and the magnitude of the spill volume of the material. The calculations cited have shown that the spill of the material within a range of speeds from 1.55 to 3.28 m/sec and a bucket filling coefficient of unity does not exceed 1% of the output of the elevator. This conclusion has received experimental confirmation.

G. A. Geniev

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

1069. Trofimov, G. I., Nonerosion velocity for sandy soils (in Russian), *Gidrotekh. Stroit.* no. 1, 50–53, 1956; *Ref. Zh. Mekh.* no. 4, 1957, Rev. 4286.

At the beginning of the paper there is a critical examination of the formula proposed by V. S. Knoroz for nonerosion velocity. Author considers that this formula (obtained on the basis of making I. I. Levi's formula more precise, by representing the numerical coefficient by a function of the Reynolds number) is not applicable to calculations, since it is impossible to determine the velocity near the bottom u_d which enters it. It is pointed out that the form of the Reynolds number assumed by Knoroz does not characterize the kinematic conditions of the flow and disregards the inhomogeneity of the alluvial sedimentation of the channel.

Further, author compares the values of the nonerosion velocities obtained from the formulas of I. I. Levi, M. A. Velikanov, V. N. Goncharov, and by I. Shamov and N. Ya. Orlov with the natural tests made by the scientific investigation department of the Leningrad Water Transport Engineering Institute; in this the velocities of the river which occurred in the post-spring flood conditions on the erratic section at the instant of stable markings of the bottom were considered nonerosion ones.

Comparison shows that the most accurate results are given by the formulas of Goncharov and Levi. Author prefers Goncharov's formula [Alluvial motion, 1938].

For consideration of the inhomogeneity of alluvial sedimentation, author makes a correction to Goncharov's formula, replacing the factor of inhomogeneity d/d_{max} by the coefficient $\varphi = d/d_{90}$ (d_{90} is the diameter of the particles corresponding to 90% on the curve of the grain size), which leads to the best agreement with the tests. N. B. Kereselidze

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1070. Walker, A. B., and Cole, W. H., Experimental investigation of critical design factors for vane-type cyclones, *Trans. ASME* **79,** 8, 1715–1721, Nov. 1957.

Many of the so-called high-efficiency mechanical collectors in use today are of the multiple-tube vane type. A basic investigation has been made on the effects of tube size, inlet-vane design, and utilization of outlet-tube vanes on the nature of these factors, and methods for obtaining higher efficiency and gas flow is demonstrated. A comparison between predicted field results from laboratory tests and actual field results is presented, and the accuracy of specific laboratory techniques in predicting field performance indicated. From authors' summary

1071. Ryley, D. J., An electrically-driven disk atomizer for high speeds of rotation, *J. Sci. Instrum.* **35,** 7, 237–239, July 1958.

Disk speeds ranging from 15,000–90,000 rev/min are attained by employing a variable speed d c motor/inductor alternator set and supplying the high-frequency output to a special induction motor carrying the disk. The apparatus is designed for continuous use at any speed, and several protective devices permit unattended operation. The speed is measured by employing a diametral hole in the high-speed shaft to admit a light beam intermittently to a photocell. The resulting signal is amplified and fed to a standard frequency meter. Disk diameters are 2, 3, 4 and 5 cm.

From author's summary

1072. Gebhardt, H., Atomization with swirl nozzles (in German), *Wiss. Zeitschr. techn. Hochsch., Dresden* **7,** 2, 249–273, 1957–58. (Condensed form, *Brennstoff-Waerme-Kraft* **10,** 8, 361–366, 1958).

Theoretical and experimental research on the atomization characteristics of swirl nozzles, in particular regarding their suitability for heavy oils (diesel oil, coal-tar oils). Rate of discharge, spray angle, and fineness of atomization were measured as functions of nozzle dimensions, injection pressure, and fuel characteristics. The drops were photographed using a spark-flash illumination, and the largest drops were considered as the measure of the goodness of atomization. The efflux coefficient of the nozzle was found to be a function of the Reynolds number. The results are represented in an uniform manner as functions of dimensionless ratios of nozzle dimensions. Spray angle was determined as a function of nozzle characteristics, orifice size, and viscosity of the liquid. Drop size depends mostly on injection pressure and viscosity of the liquid. By means of the found relationship it is possible to apply the results with water to other liquids. Diagrams are given whereby swirl nozzles can be designed for a great variety of operational conditions. Work of previous investigators is discussed. Experimental setup is illustrated and procedure described. Sample photographs of drops, and distribution of spray in a cross section are given. Nomograms for drop size were constructed.

K. J. DeJuhasz, Germany

1073. Rasbash, D. J., The production of water spray of uniform drop size by a battery of hypodermic needles, *J. Sci. Instrum.* **30,** 189–192, June 1953.

In research on extinction of fires by water sprays it was necessary to produce sprays of uniform and controllable drop size, up to rates of flow of the order 1 g/min per cm² of the fire area. Use of spinning disk was ruled out by the practicable rate of flow being less than the required rate. A spray apparatus consisting of 169 hypodermic needles of 0.22-mm inside diam was used, with air atomization; drop size could be controlled by the pressure on the water and the pressure of the atomizing air. Uniformity of drops decreased with increasing rate of flow. The test area was 96 cm² located at 120 cm below the hypodermic needles. Layout of spray apparatus is illustrated and described; drop size distribution histogram is shown for the hypodermic needle battery, and, for comparison, for an impinging jet spray, showing the much greater uniformity of the former. Spatial distribution of spray is given for the various drop sizes. K. J. DeJuhasz, Germany

1074. Tanasawa, Y., Kurabayasi, T., and Saito, Y., On the generation of uniform drops with rotating nozzles, *Trans. Jap. Soc. Mech. Engrs.* **22,** 116, 279–284, 1956.

This work is a continuation to Tanasawa and Toyoda (1955), to which the authors refer. Authors found that drops falling from the end of a small diameter tube were not accompanied by satellite droplets, therefore they attempted to produce a stream of uniform drops by means of rotating nozzles, and checked the results with theoretical considerations. Their main findings: (1) A parameter can be formed from the tube diameter, specific gravity and surface tension of the liquid; if this is below a certain value, uniform drops can be produced; (2) a formula is given for the maximum drop diameter at low flow values; (3) the drop diameter decreases with decreasing flow rate to its minimum value until a critical range is reached where the mode of flow changes from dripping to smooth laminar flow. This is a report of a phase of the extensive spray investigations carried on by the authors at Tohoka University.

K. J. DeJuhasz, Germany

1075. Ramanadham, R., and Vidyavathi, K., Size distribution of raindrops from layer type clouds in tropics, *J. Meteorol. Soc. Japan* (2), **35,** 4, 221–226, Aug. 1957.

A preliminary study of the size distribution of raindrops from layer-type precipitation in tropics has been made. The large deviations in the size distribution which have been ignored by past workers, in their attempt to develop an emperical relationship between the drop size and intensity of rainfall, have been examined. The large deviations from "Marshall-Palmer distribution" in the observed spectral distribution of drops at the ground level are explained in terms of the modification the drop-size spectrum undergoes, in the intervening space between the level or origin of raindrops and ground due to (a) growth of raindrops by accretion with cloud droplets, (b) differential rates of evaporation of raindrops of different sizes in falling from cloud to ground, and (c) coalescence between raindrops of different sizes during their fall from cloud to ground. From authors' summary

Porous Media

1076. Nasyrov, R. M., Problem of determining the pressure field in a seam of variable permeability (in Russian), *Uch. zap. Kazanskogo in-ta* **116,** 1, 61–65, 1956; *Ref. Zh. Mekh.* no. 4, 1957, Rev. 4471.

On the assumption that a liquid is incompressible and homogeneous, the motion of the liquid is subjected to the linear law of

filtration, the permeability of the seam $k(x, y)$ is variable, the function of pressure $p = p(x, y)$ is determined from the equation

$$\frac{\partial}{\partial x}\left(k\frac{\partial p}{\partial x}\right) + \frac{\partial}{\partial y}\left(k\frac{\partial p}{\partial y}\right) = 0 \qquad [1]$$

where $p = p_0$ on the feeding contour L and inside the region taken up by the petroleum there are n apertures. By introduction of the variable $u = p\sqrt{k}$, equation [1] is reduced to the form

$$\Lambda\sqrt{k}u - u\Lambda\sqrt{k} = 0 \quad \left(\Lambda = \frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2}\right)$$

A solution of the problem is given for the case when the function $\sqrt{k}(x, y)$ satisfies Helmholtz's equation

$$\Lambda\sqrt{k} + \alpha^2\sqrt{k} = 0$$

The solution is given in the form of the sum of the two functions u_1 and u_2

$$u = u_1 + u_2$$

V. A. Karpychev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1077. Marion, H., and Saubestre, P., Variation of the physical characteristics of oils in deposits (in French), *Rev. Inst. Fr. Petrole et Ann. Comb. Liq.* **13,** 5, 767–779, May 1958.

This review of the literature reports the variations in the physical properties of hydrocarbon compounds in an oil field. First is given the results of experimental studies of some fields where inequalities of temperature and pressure give rise to such phenomena.

As an appendix, a review has been added, with comments, of the theoretical work done in 1938 by Sage and Lacey on the isothermal equilibrium of a hydrocarbon compound.

From authors' summary

1078. Juhasz, J., An investigation into percolation phenomena (in Hungarian), *Hidrologiai Közlöny* **38,** 1, 24–41, Feb. 1958.

New contributions of author are based on the Poiseuille equation and the theory of effective cross section. Using Mitserlich's hygroscopic quality gives the following equation for seepage velocities: $v = n^4 r_0^2 I / 3.75\,\mu$, where n is porosity, r_0 radius of soil pipe, I gradient of flow. On microseepage author uses Vageler's theory of accractive force of water, introduces $\alpha = 3.10^{-11}$ as static friction coefficient of water, and proves the existence of lower limit gradient in fine-grained soils if a prevailing pressure exists in the soil. Equation of limit gradient: $I_0 = 1.88\,\alpha P_r\, n^4 r_0$ where P_r is the hydrostatic pressure. Equation answers problems on impermeability of clay cores, etc.

Investigations of capillary rise are also modified by introduction of the varying effective cross section by varying pressure. Reviewer believes that author's important contributions will be a great help in investigating related problems.

A. Simon, USA

1079. Stegemeier, G. L., and Matthews, C. S., A study of anomalous pressure build-up behavior, *J. Petr. Technol.* **10,** 2, 44–50, Feb. 1958.

In one field in South Texas, approximately 75% of the pressure build-up results show a characteristic "hump" (i.e., the pressure builds up and then falls off) which makes interpretation by standard methods impossible. Correlation of size and time of hump with formation permeability, well productivity index, and method of completion led to the tentative conclusion that the humps were caused by segregation of gas and oil in the well bore after closing-in. This conclusion was confirmed by performance of simple laboratory bubble-rise experiments, by theoretical bubble-rise time calculations, and by a detailed calculation of *PVT* behavior in the well bore of a particular well on which accurate surface and bottom-hole pressure measurements were made.

The hump behavior has since been found to occur in many other fields. The cause, however, is not the same in all cases. In some of these the hump is traceable to leaks in the tubing which allow influx of gas from the annulus after closing in. In other cases the hump is traceable to leaks in the device separating pay horizons in dually completed wells.

It is concluded that the recording of both surface and bottom-hole pressures is desirable in wells which show an anomalous build-up behavior. A number of field examples are discussed where use of both sets of measurements enables the cause for anomalous behavior to be found, and a reasonable interpretation of bottom-hole pressure to be made. From authors' summary

1080. Huard de la Marre, P., Solution of infiltration problems with free surface, with the aid of electrical analogies (in French), Publ. Sci. Tech. Min. Air, France, no. 340, 154 pp., 1958.

Book gives an account of infiltration problems with free surface, studied with the help of electrical analogies. Problems of infiltration through dams are considered in detail.

Book is divided in four chapters. In the first one, having recalled the fundamental equations deduced from the Darcy-Ritter law, author shows the direct electrical analogy (in which the electrical current corresponds to macroscopic velocity, the resistivity to permeability, and the electrical tension to the hydraulic head) and the inverse analogy (in which the electrical tension corresponds to the stream function). The arrangement of experimental researches and their precision is then discussed.

Problems of plane flow in porous media, with nonuniform permeability, are considered in the second chapter; the theoretical point of view is first explained, then the technical execution of the experiments. This is the most important chapter.

Analogical models in three dimensions are discussed in the third chapter; these models can be obtained with steady material or using an electrolytic tank; for both cases author refers to some solutions.

Some problems of nonstationary motion are described in the fourth chapter.

It must be pointed out that the book is probably the first one which studies the problems of infiltration through electrical analogies, but theoretical and experimental researches on these methods appeared about thirty-six years ago [Pawlosky, in Russian, 1922, for plane models; Puppini, in Italian, 1922 for models with electrolytic tank). Many other authors have since applied the methods to practical problems; reviewer remembers the Indian researches of 1932–1936 (in English; see Indian Academy of Sciences and Punjab Research Institute). Reviewer thinks that a list of references would be appreciated, but no Italian, German, Russian nor Indian research is quoted here. G. Supino, Italy

1081. Houpeurt, A., Fluid flow and underground hydrocarbon levels (in French), *Rev. Inst. Fr. Petrole et Ann. Comb. Liq.* **12,** 12, 1219–1223, Dec. 1957.

The movements of hydrocarbons in the subsoil differ from those of underground water, for reservoir-rocks usually contain both water and hydrocarbons, and, owing to this biphasic saturation, their flow shows special characteristics. Furthermore, owing to its low viscosity, natural gas does not flow according to Darcy's law.

A few monophase flows are encountered, however, which conform with the usual diffusivity equation. Measurements of flow and pressure are the source of valuable information on the productive layers. From author's summary

1082. Motyiakov, V. I., Solution of inverse problems on stationary flow in underground hydraulics by means of electric grid models (in Russian), *Zh. Tekh. Fiz.* **27,** 2, 364–367, Feb. 1957.

The steady-state strength of sinks (in an oil field, for example) is found from pressure measurements at various points. Solution is obtained from an analogous electric grid of passive elements.
R. E. Gaskell, USA

1083. Rogovskaya, N. V., The results of filtration tests on irrigation areas (in Russian), *Sov. Geologiya* no. 44, 34–46, 1955; *Ref. Zh. Mekh.* no. 4, 1957, Rev. 4498.

Tests were made on an area of 2.5 million hectares, and on that basis charts were made on a scale of 1 : 100,000 of the water permeability of the aeration zone and of the water-bearing stratum. For determining the filtration coefficient K, more than 1200 fillings of the bore holes were made, as well as 800 pumpings from wells and 600 tests on stone blocks in laboratory conditions. The territory was characterized by variegated petrological origin of the soil and varied mineral salt content.

Determination of K in the aeration zone by filling of the bore holes and from the blocks showed: (a) no connection between the grain size of the deposits (characterized by the clay particle content of diameter ≥ 0.005 mm) and the water permeability; (b) a sharp difference (up to 100 times), usually toward exceeding the values of K determined in field conditions, from those which are usually assumed for soils similar in their mechanical composition; (c) that the permeability of soils in natural conditions differs considerably, and, as a rule is higher than the permeability in blocks, and tests in laboratory conditions cannot correct the field tests; (d) that over a period of time (7 to 10 days) the coefficient of filtration in blocks varies considerably (up to 10 times), increasing for some and decreasing for others, which is explained by coagulation and dispersion as a result of the variations in the salt content of the soil and filtration.

Determination of the filtration coefficient of the water-bearing stratum by the pumping method gave the following results: (a) When the value of K is calculated by the DuPuis-Tima formula (for complete wells) and that of Girinskii (for incomplete wells), results are obtained which coincide fairly closely when the length of the filter immersed in the water-bearing stratum is nearly the same as the distance between the central and the observation wells. (b) The mean values of K determined from individual pumpings are 20–40% greater than those found from group pumpings. (c) The index of the mechanical composition of the soil—the mean weight of particles $d \leq 0.01$ mm, called the "soil index" by S. F. Korobkin [*Gidrotekhnika i Melioratsiya*, no. 8, 1949]—has no connection with the value of K.
S. F. Aver'yanov
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1084. German, M. Ya., Relation of the hydraulic resistance of a layer of metallurgical coke to the composition of the screen (in Russian), *Trudi Dnepropetr. Khim.-Tekhnol. In-ta* no. 4, 162–168, 1955; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5819.

1085. Efros, D. A., Determination of relative permeabilities and distribution functions when oil is displaced by water (in Russian), *Doklady Akad. Nauk SSSR (N.S.)* **110**, 5, 746–749, Oct. 1956.

1086. Pilatovskii, V. P., Use of certain contour integrals in problems concerned with the pressure percolation of incompressible fluids to wells (in Russian), *Doklady Akad. Nauk SSSR (N.S.)* **110**, 5, 742–745, Oct. 1956.

Flow of liquid in a laminated permeable medium is evaluated with the aid of Cauchy's integral formula. Paper is limited to derivation, with no examples given.
R. E. Gaskell, USA

1087. Gandin, L. S., and Soloveichik, R. E., On the problem of the laminar boundary layer at a porous wall (in Russian), *Prikl. Mat. Mekh.* **20**, 5, 663–665, Sept.–Oct. 1956.

Author solves the boundary-layer problem with a given constant suction or emission $\mp W$ at the wall, that is, a generalization of the classical Blasius problem. He uses the approximate method (zero and first approximations) by M. E. Shvetz, simpler and of same precision as Pohlhausen's. Approximate formulas obtained by author are valid for both suction ($W < 0$) and emission ($W > 0$). Author gives graphs $\delta(x)$ for both cases. For suction, when $x \to \infty$, $\delta \to Const$ (and also tangential stress $\to const$), and author claims this is valid also for W variable and gives example. Reviewer observes example that $W \to Const$ for $x \to \infty$, while for a W that *remains* variable, δ must also be variable. For emission results show that $\delta \to \infty$, and author obtains from his formula a true description of the flow-separation phenomenon that occurs in this case, with a counter-flow in the wake. A paradoxical result of negative tangential stress on the wall is obtained. As negative skin friction would be nonsense, reviewer suggests a further study of this point. Two explanations may be suggested: (1) that the front part of the wall (before the separation point) yields a greater resistance than the negative force on the whole tail-part to infinity, (2) that the wall that emits fluid is a variable mass-system with a sort of jet propulsion.
N. Krivoshein, Argentina

1088. Karavaev, N. M., and Maikop, V. P., Method for determining heat loss coefficients in porous-material layers (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 6, 89–100, June 1956.

Author begins with a short survey of theoretical foundations of methods for determining heat loss coefficients in porous material layers. The theoretical problem leads to solving two partial differential equations for unknown temperatures θ_g, θ_s of the flow and layer, respectively. The well-known solution of Shumann uses Bessel functions and is expressed in two (dimensionless) variables Y, Z, which are in a closed relation with old variables H, τ and with the heat loss coefficient α_v to be found. Graphs are presented for these functions as functions of Z if Y is fixed.

Author then investigates those points of these graphs at which $Y = Z$. He shows that these points have a certain physical meaning, and on the basis of his investigations he presents a transcendental equation for determining Y. Having Y, the coefficient α_v can then be simply found.

Finally, author presents a detailed description of the experiment, together with numerical calculation, which makes clear the utility and applicability of his theory and which will be surely appreciated by the readers interested in practical applications.
K. Rektorys, Czechoslovakia

1089. Borisov, Yu. P., Hydrodynamic calculations in an elastic system (in Russian), *Trudi Vses. Neftegaz-N.-I. In-ta* no. 8, 208–231, 1956; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5803.

A solution is found for the determination of the distribution of the pressure of the liquid in a homogeneous infinite layer, with an elastic system of filtration operating. Cases are investigated where the liquid is withdrawn from the layer through (1) a single well of negligibly small radius, (2) an encircling battery of wells and (3) a rectilinear drainage gallery; the discharge of liquid withdrawn appears to be variable with time. Author proceeds from the known integration presentation of the distribution of pressure through the variable discharge. The suggested approximate solution is based on the selection of some approximate expressions as the nuclei of this integral presentation, which gives the possibility of accomplishing in its final form the integration with dependence of the yield on time according to the whole number stepped principle. In the case of a yield, changing according to the linear principle, calculation formulas, curves and tables are produced, enabling a solution to be constructed also for a yield changing on time according to the principle expressed by an arbitrary broken line. It should be noted that for cases (1) and (3) precise solutions of all the problems investigated by the author have been given in an elementary form through simple automodelling solu-

tions, which, apparently, were unknown to the author [see G. I. Barenblatt, *Prikl. Mat. Mekh.* **16,** no. 1, 1952]. Consequently, for these cases, the somewhat complicated technique of approximate solutions advocated by the author does not appear to be justified.

G. I. Barenblatt

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Geophysics, Hydrology, Oceanography, Meteorology

(See also Revs. 795, 796, 831, 832, 900, 1075)

1090. Sakuma, S., and Nagata, T., Physical volcanology (in English), Encyclopedia of Physics, Vol. 48, Geophysics 2, Springer-Verlag, 1957, 982–1011.

A brief but comprehensive review of the physical effects of volcanic activity, with a list of major references. Topics discussed include movement and physical properties of ejected materials, deformation of the earth's surface, earthquakes of volcanic origin, geophysical exploration of volcanic structure, and the energy balance of volcanic phenomena. A valuable feature is the authors' care throughout the text to point out unsolved problems and to suggest areas for further research.

F. G. Blake, Jr., USA

Book—1091. Long, R. R. (editor), Fluid models in geophysics (Proceedings of the First Symposium on the Use of Models in Geophysical Fluid Dynamics) Washington, D. C., 1956, U. S. Government Printing Office, 162 pp. $2.25.

Book contains the papers presented at the First Symposium on the Use of Models in Geophysical Fluid Dynamics, held at Johns Hopkins University, September 1 to 4, 1953. This excellent summary of the use of models in investigating fluid systems contains the following papers: "Dimension analysis and similarity" by Stanley Corrsin; "Remarks on the problem of motions in a rotating fluid" by George Morgan; "A survey of certain thermally and mechanically driven fluid systems" by Dave Fultz; "On convective instability of a rotating fluid" by H. L. Kuo; "Explanation for the existence of two regimes of flow in a rotating heated cylindrical vessel" by E. N. Lorenz; "Results of recent observational studies of the southern hemisphere circulation" by M. J. Rubin; "Some techniques for laboratory study of the ocean circulation" by W. S. von Arx; "Fluid motion in the earth's core" by R. Hide; "Free convection due to boundary sources" by C. Yih; "Models of small-scale atmospheric phenomena involving density stratification" by R. Long; and "A general solution for the celerity of gravitational waves in a stratified fluid" by G. S. Benton.

In the opinion of the reviewer, these eleven papers represent recent efforts to obtain a body of theoretical knowledge of ideal fluids possessing vorticity and will provide a reservoir of basic theoretical work to guide the experimenter in the use of models when studying rotating fluids or fluids with density stratification. This volume is strongly recommended to research workers who are investigating fluid systems by the use of models.

L. A. Pipes, USA

1092. Brakensiek, D. L., Fitting a generalized log-normal distribution to hydrologic data, *Trans. Amer. Geophys. Un.* **39,** 3, 469–473, June 1958.

A statistical distribution is developed which makes it possible to fit a wide range of positively skewed hydrologic data. It is shown that the general least-squares fitting equations will reduce to simple forms for fitting a normal, log-normal, or extreme-value distribution to data. Two fitting processes are developed for fitting data by the so-called generalized log-normal distributions. Examples are given for illustrating the fitting procedures.

From author's summary

1093. Fel'zenbaum, A. I., Relation of the wind to the water level and to steady currents in shallow sea (in Russian), *Dokladf Akad. Nauk SSSR (N.S.)* **109,** 1, 80–83, July 1956.

1094. Saunders, K. D., A power-spectrum equation for stationary random gusts, including a sample problem, *J. Aero. Sci.* **25,** 5, 295–300, May 1958.

A hypothetical probability model of random rectangular gust pulses (random in occurrence, in intensity and in duration) is postulated and an analytic expression of the associated power spectrum is derived in terms of several statistical parameters of the random variables. The result obtained for the power spectrum is of a more general form than has been in common use. However, the applicability of the result is not clear inasmuch as little information is available in a form suitable for determining the values of the statistical parameters involved. Author unfortunately makes use of the statistics on effective or derived gust velocities which are not suitable for this purpose inasmuch as they actually represent the statistics of the airplane normal acceleration response rather than the gust input itself. In particular, the numerical results given in the section on extreme gust spectra are subject to question for this reason. The sources of the data and the procedures used in deriving these numerical results are not clearly stated. Thus the significance of the results obtained on the scale and the intensity of the turbulence is not clear and should be viewed critically.

The author is apparently not aware of a number of related studies by the NASA on this subject [*NACA TN* 3362, 3540, and *NACA TR* 1272]. In particular he overlooks the fact that, for a given weather condition such as clear air turbulence or thunderstorms, the intensity of the turbulence or mean-square-gust velocity varies over a wide range. Where the values he gives for the extreme gust spectra fit in is not clear.

H. Press, USA

1095. Jordinson, R., Flow in a jet directed normal to the wind, *Aero. Res. Counc. Lond. Rep. Mem.* 3074, 4 pp. + 24 figs., 1958.

Experiments to study the flow in an air jet, which is ejected normal to an air stream from an orifice in a plane floor, have been made for several values of the ratio of wind velocity to jet exit velocity. The path of the jet and the shape of the jet cross section were determined; this cross section was found to be of horseshoe shape away from the orifice. It was also found that the jet draws up with it air from the floor boundary layer.

From author's summary

1096. Kawano, M., The coefficient of eddy diffusivity estimated by the method of atmospheric electricity, *J. Meteor. Soc. Japan* (2) **35,** 6, 339–342, Dec. 1957.

The relation between the atmospheric electric field and the coefficient of eddy diffusivity is discussed under the following assumptions:

(1) The vertical distribution of the space charge is controlled by eddy diffusion near the ground.

(2) The space charge transported into a unit volume of the atmosphere by eddy diffusion is balanced by the space charge dissipated by the atmospheric electric conductivity in the same unit volume.

Using the observed results of the atmospheric electric field, conductivity and space charge obtained at Hongo, the diurnal variation of the coefficient of eddy diffusivity in each season is estimated. The value is 5.0×10^4 cm²/sec in the daytime and 5×10^3 cm²/sec at night. From author's summary

1097. Komabayasi, M., Some aspects of rain formation in warm cloud. II. Liquid water content as a function of upward velocity, *J. Meteor. Soc. Japan* (2) **35,** 5, 266–277, Oct. 1957.

The liquid water content of a precipitating warm cloud is expressed as a function of upward velocity, taking into account the difference between the rate of condensation which accumulates the liquid water in the cloud and the rate of rainfall, which carries it out of the cloud. As for the condensation nuclei of raindrops, a simplified analytical expression of Woodcock's size distribution (1953) is used.

The liquid water content in a steady state is found to be proportional to 1/3 power of the upward velocity, the numerical values of which, for example, are 0.42, 0.90 and 1.93 g/m³ for upward velocities 10 cm/sec, 1 and 10 m/sec, respectively, in a typical condition for the cloud and sea-salt nuclei.

In transient state, the liquid water content of the cloud is found to take a maximum at a certain time after the beginning of cloud formation if upward velocities are larger than 10 cm/sec, thereafter it begins to decrease due to falling out of raindrops and approaches a value of steady state.

Preferred appropriate upward velocity for initial raindrop formation due to the presence of large sea-salt nuclei is differentiated from that due to the coalescence mechanism under the presence of various size distribution of nuclei.

Effect of the entrainment of surrounding air into cloud on the salinity of rain water is qualitatively discussed from the viewpoint of nuclei budget of the cloud.

From author's summary

1098. Vorontsov, P. A., Vertical movements of the air in the summer in the neighbourhood of the Tsimlyanskii water basin (in Russian), *Trudī Gl. Geofiz. Observ.* no. 56, 19–35, 1956; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5775.

Results are published of the investigations made in expeditions of the principal geophysical observatory, named A. I. Voikov, during the summer of 1954 in the region of the Tsimlyanskii water catchment area. The observations were carried out by means of calibrated pilot balloons to determine the following: the vertical velocities of macropulsation W cm/sec, the vertical components of the path of vortex L m, the period of conservation of the pulsation of one value T sec, the velocity of wind V m/sec, the angle of inclination of the air flow to horizon d. An examination was carried out of the 24-hourly course of the calculated values given above, separately for ascending and descending movements in the layer above the earth up to 200 m and from 10 m to 200 m. The 24-hourly progress of W and L was well-expressed and reached its maximum in the midday hours (W = 49 cm/sec and L = 68 m) and its minimum in the morning (W = 9 cm/sec and L = 7 m). The same relations were also observed for the descending motions. The duration of pulsation T has two maxima: at 8 and 16–18 hours. Angle α changes from 1.4° in the morning to 5–7° in the day. All the characteristics of the ascending flows show, to a somewhat greater degree, corresponding characteristics in the descending movements. The clear diurnal progress has also a turbulence coefficient, determined by means of the data of pilot balloon observations using the method devised by D. L. Laikhtman [*Trudī Gl. Geofiz. Observ.* 37, (99) 1952]. From the morning up to midday the turbulence coefficient in the 100–200 m layer increases fourfold. The observations indicate an increase in the velocity of the air current in its transition from dry land to a water surface and a decrease of the vertical velocity. The equilibrated balloon pilot is significantly lowered when passing over from the bank to the basin, while the velocity of its horizontal migration increases by 1.08 to 1.90 times. Under intensive convection the movement of the equilibrated balloon exhibits features out of the ordinary: the balloon is caught up in the ascending flow and moves upwards; however at a certain height (mornings 60–65 m, daytime up to 300 m) its vertical movement stops. The height with maximum vertical velocity has also a well-defined diurnal course (50 m at 6 hours, 120–150 m at 8–12 hours, 240 m at 14 hours). Further, the characteristics of dust vortices are given, the increase in vertical velocity up to a certain height, corresponding to the height of the dust column, and then a sharp diminution. The magnitude of the tangential pressure is computed and its critical value is determined as the force required to break away dust from the earth's surface (τ = 200–300 g/cm/sec²).

E. A. Burman

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1099. Nicolet, M., Temperature at the limit of the thermosphere (in French), *Acad. R. Belgique, Bull. Cl. Sci., Brussels* **43,** 6, 731–739, 1957.

A steady conductive heat flow in the thermosphere with a temperature of 2250 K at the critical level implies a flux of coronal energy actually trapped by the earth's atmosphere of the order of 0.7 erg cm^{-2} sec^{-1}.

From author's summary by H. Riehl, USA

Naval Architecture and Marine Engineering

(See Rev. 616)

Friction, Lubrication and Wear

1100. Goodzeit, C. L., Compatability of metals in bearing contact, ASME Design Engng. Conf., Chicago, Ill., Apr. 1958. Pap. 58-MD-9, 11 pp.

Antiseizure properties, resistance to fatigue from dynamic loads, corrosion resistance, toleration of dirt in lubricant, are some of the basic considerations in selecting journal-bearing metals. Other factors, such as operating temperatures, manufacturing techniques and design, are equally important.

From author's summary

1101. Barwell, F. T., Techniques for surface examination and their contribution to our knowledge of friction and wear, *Lubrication Engng.* **14,** 9, 391–397, Sept. 1958.

The response of a surface to a wearing process may be characterized by (a) changes in topography, (b) changes in chemical nature, (c) changes in the physical structure.

The various methods available for study of these effects are reviewed, and the attempt is made to show them in perspective. A survey is made of the factors entering into the wear process together with an analysis of the common machine elements from this point of view.

The approach is illustrated by reference to Mechanical Engineering Research Laboratory work on scuffing, and the power and

limitations of the electron microscope as a research method are discussed. From author's summary

1102. Wieneke, F., Investigation of winding and friction phenomena related to shafts and other rotating machine parts (in German), *VDI-Forschungsheft* **463,** 23, 28 pp., 1957.

1103. Nisnevich, A. I., Interaction of friction surfaces in mechanical wear processes (in Russian), *Izv. Akad. Nauk. SSSR, Otd. Tekh. Nauk* no. 8, 122–127, Aug. 1956.

Book—1104. Vogelpohl, G., Operationally safe journal bearings: Computational methods for design and operation [Betriebssichere gleitlager: Berechnungsverfahren fur konstruktion und betrieb], Berlin, Springer-Verlag, 1958, xi + 315. DM 46.50.

Since the latest edition of the book by E. Falz, "Grundzüge der Schmiertechnik" (Fundamentals of lubrication engineering), was issued by the same publisher in 1931, no book of a similar scope had been published in the German language. The present book can be regarded as a worthy successor to the former, which did so much in disseminating knowledge about lubrication among German-reading machine designers.

The author has succeeded quite well in casting the relevant computational methods in a form workable enough for designers, and yet keeping them firmly rooted in the modern theories of hydrodynamic lubrication, which more often than not appear, at least at first sight, rather complicated. A typical example is provided by the following "volume rule", which is here cited as it is hardly known outside the author's country, namely:

$$P = C \cdot \eta \cdot n \cdot Vol,$$

where the permissible load P (in kg), at which, in the sleeve bearing concerned, contact will just occur between the surfaces of the journal and the bearing, is expressed in a surprisingly simple manner in terms of viscosity η (in centipoise) at the operating temperature, the rotational speed n (in rpm) of the journal, and the volume, *Vol* (in litres), of the journal piece supported by the bearing. From numerous checks that have been carried out for a very wide range of bearing sizes, from miniature bearings up to the largest sleeve bearings so far made (about 5-ft diameter), it is proved that, with normal machining accuracy and finish and with deformations of the rubbing surfaces that are not too excessive, the above factor C ranges only from about 1 to 2.

The concept of viscosity, with which many machine designers do not yet seem to be familiar enough, is carefully elucidated, including the influence of temperature on this "constructional" lubricant property, which is so essential in hydrodynamically lubricated machine components.

For predicting the final temperatures reached in sliding bearings in the steady state, computational methods are developed that are simpler than most of those which have been published so far. Nevertheless these methods may be deemed to be sufficiently accurate for most practical purposes. Published data on the heat dissipation in sliding bearings are subjected to a critical investigation and comparison.

The various computational methods are explained by means of about fifty numerical examples from actual practice.

Some attention is devoted also to hydrostatically lubricated sliding bearings, that is, bearings in which the pressure formation aimed at in the lubricant film is generated by means of a separate pump that feeds the lubricant under a pressure sufficiently high to push the journal or collar apart from the bearing surface. The hydro*static* method presents great advantages in several cases, for instance those in which a combination of a heavy load with a low speed of the journal renders the classical hydro*dynamic* method of lubrication impossible.

Further, author deals with the possibilities inherent in sliding bearings lubricated with air or another gas, either aero*dynamic* or aero*static* bearings. On account of the small viscosity of air, the possibilities of aerodynamic bearings, which are economically so attractive because of the free availability of this particular lubricant, can be materialized only when loads are comparatively low and, at the same time, journal speeds are sufficiently high (compare the above "volume rule," which applies also to these cases, provided that the operating conditions are such that the effects of the compressibility of the air can be neglected).

All in all this is a book that can be recommended warmly to all those machine designers who wish to have at their disposal modern and reliable methods for computing sliding bearings. The size of the book need not be a deterrent. After all, as is observed by the author himself, complete enough manuals and catalogs for the computation and selection of roller bearings are neither less voluminous nor less simple.

It is hoped that when the next edition is to appear, enough knowledge will meanwhile have been developed about the performance and theory of dynamically loaded bearings, that is, bearings subjected to fluctuating loads and/or oscillating motion of the journal, to enable the author to evolve also workable computational methods for such bearings. H. Blok, Holland

1105. Nikitin, A. K., Steady motion of a viscous incompressible fluid between a pin and a bearing (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **108,** 3, 405–408, May 1956.

The plane problem of a journal rotating in a circular bearing containing a viscous fluid is worked out, including the inertia of the lubricant. The nonlinear differential equation is solved by a method of iteration, and under the proper restrictive conditions the solution is shown to be unique. The components of the force on the journal and the frictional moment are calculated and their dependence on the Reynolds number shown.

E. Saibel, USA

1106. Osterle, J. F., and Hughes, W. F., Effect of inertia on wide angle flow in hydrodynamic lubrication, *Engineer, Lond.* **204,** 5305, p. 449, Sept. 1957.

Authors show that neglect of lubricant inertia in slider bearing theories of W. Lewickie [AMR **9** (1956), Rev. 2417] and A. A. Milne lead to pessimistic load capacities at large slider angles. For a slider velocity of 100 ips and an average pressure of 100 psi the error involved is approximately 5% for a 6-degree inclination of a 1-inch slider. H. E. Brandmaier, USA

1107. Berry, L., Solid lubricant coatings, ASME-ARS Joint Aviation Conf., Dallas, Texas, Mar. 1958. Pap. 58-AV-20, 27 pp.

Quantitative data on some of the variables affecting the performance of dry-film lubricants are presented. The tests, made on a Falex Lubricant tester, show that optimum performance can be obtained only if the variables affecting their use are known and taken into account. From author's summary

1108. Hill, H. C., Slipper bearings and vibration control in small gas turbines, ASME Gas Turbine Power Conf., Washington, D. C., Mar. 1958. Pap. 58-GTP-6, 9 pp.

Several new principles of bearing design have proved effective in improving the reliability and smoothness of small gas turbines. The key development was the tilting-slipper thrust bearing which not only provided important radial clearance, but also made possible higher speeds at higher thrust loads. One of the unique features considered important for performance and low production costs is that the slippers float in their retainers instead of having fixed pivots. From author's summary

1109. Downham, E., The influence of plain bearings on shaft whirling, *Aero. Res. Counc. Lond. Rep. Mem.* 3046, 12 pp. + 3 tables + 23 figs., 1958.

Experiments are described which show the effects of bearing length, bearing clearance, and lubricant viscosity on the critical whirling speeds of a single-shaft rotor system supported in plain bearings.

The critical speed of a two-bearing-shaft rotor system is shown to depend upon rotor unbalance for bearing of normal clearance. When the clearance is small relative to the bearing length, unsymmetric stiffness characteristics are obtained and produce two critical speeds instead of one.

The lubricant in a drip-feed bearing is shown to have a stiffening effect, with consequent increase of critical whirling speed. It is also shown that the critical whirl amplitudes with dry bearings can be appreciably larger than those obtained with lubricated bearings. From author's summary

1110. Eilon, S., and Saunders, O. A., A study of piston-ring lubrication, *Instn. Mech. Engrs. Proc.* **171,** 11, 427–462, 1957.

Paper describes an experimental study of the lubrication between a one-ring piston assembly and a cylinder. Instantaneous friction forces of the piston assembly were recorded by means of a special apparatus with a stationary piston and a reciprocating liner. Tests were carried out to determine the effects of viscosity, speed, and pressure on the friction, from which the oil film thickness under the ring was calculated. A suggested lubrication theory of piston rings is given, based on a balance of forces acting radially on the ring, leading to a theoretical formula for calculating the ring film thickness, which is in reasonably good agreement with the experimental results. Suggestions are made for the design of rings to give improved friction and heat transfer and to reduce cylinder wear, especially in the initial running-in period. From authors' summary

1111. Dykes, P. de K., An investigation into the mechanism of oil loss past pistons, *Instn. Mech. Engrs. Proc.* **171,** 11, 413–426, 1957.

The mechanism of oil loss past pistons was investigated in a laboratory test rig in which a piston was both reciprocated and subjected to gas pressures. The investigation brought to light the following facts, and it is believed that this is the first time that they have been demonstrated:

(1) Oil control is a two-way and not a one-way problem. The only reason why the rate of oil consumption is reasonably small in most engines is that, although a large amount of oil flows towards the combustion chamber past the rings during part of the engine cycle, nearly all of it returns to the sump during the remainder of the cycle.

(2) The various routes permit surprisingly large rates of oil flow in both directions past rings. This applies even with good rings.

(3) If oil is added to the combustion chamber, a good ring arrangement will pass it to the sump at a rate up to many thousand times larger than the normal rate of oil consumption with the same arrangement.

(4) The piston lands, and the top land in particular, play an important role in deciding the rate of oil consumption. If some oil has passed the rings it may be thrown into the combustion chamber and be lost; alternatively, an effective top land may retain this oil until by one method or another it is returned to the sump. From author's summary

Books Received for Review

AMES, J. S., and MURNAGHAN, F. D., Theoretical mechanics; An introduction to mathematical physics (unabridged republication of 1929 edition), New York, Dover Publications, 1958, ix + 462 pp. $2.00 (paperbound).

BANO, I., Hydraulika V Prikladoch, Bratislava, Slovenske Vydavatel'stvo Technickej Literatury, 1956, 681 pp. Kcs 64,20.

BOWMAN, F., Introduction to Bessel functions (unabridged second edition), New York, Dover Publications, 1958, x + 135 pp. $1.35 (paperbound).

DEFANT, A., and DEFANT, F., Physikalische Dynamik der Atmosphare, Frankfurt, Akademische Verlagsgesellschaft, 1958, xv + 527 pp.

DOW, R. B., Fundamentals of advanced missiles, New York, John Wiley & Sons, Inc., 1958, xvi + 567 pp. $11.75.

FORSYTHE, G. E., and ROSENBLOOM, P. C., Numerical analysis and partial differential equations; Contemporary state of numerical analysis; linear partial differential equations (Surveys in Applied Mathematics, Vol. V, New York, John Wiley & Sons, Inc., 1958, x + 204 pp. $7.50.

FRANKLIN, P., An introduction to Fourier methods and the Laplace transformation (unabridged reprint of 1949 edition published under the title Fourier Methods), New York, Dover Publications, 1958, x + 289 pp. $1.75 (paperbound).

HOHN, F. E., Elementary matrix algebra, New York, the MacMillan Co., 1958, xi + 305 pp. $10.

Hydrologicka bibliografie za rok 1956, Praha-Podbaba, Vyzkumny Ustav Vodohospodarsky, 1958, 219 pp. (paperbound).

KAPLAN, W., Ordinary differential equations, Reading, Mass., Addison-Wesley Publishing Co., 1958, xv + 534 pp. $8.50.

KAYS, W. M., and LONDON, A. L., Compact heat exchangers, New York, McGraw-Hill, 1958, xii + 156 pp. $6.

Proceedings of the 8th International Astronautical Congress, Barcelona 1957, Wien, Springer-Verlag, 1958, vii + 607 pp. $23.80.

Proceedings of the National Specialists Meeting on Dynamics and Aeroelasticity, Fort Worth, Texas, Nov. 1958, New York, Institute of Aeronautical Sciences, 1958, 135 pp. $6.00 (paperbound).

SCHIELDROP, E. G., The air; Conquest of space and time, New York, Philosophical Library, Inc., 1958, 256 pp. $12.

THOMPSON, C. H., Fundamentals of pipe drafting, New York, John Wiley & Sons, Inc., 1958, 66 pp. $3.50 (paperbound).

TRAUPEL, W., Thermische Turbomaschinen, Vol. I: Thermodynamische und Stromungstechnische Grundlagen, Auslegung, Schaufelgitter, raumliche Stromung, Berechnungsunterlagen, Charakteristiken, Berlin, Springer-Verlag, xii + 407 pp. DM 58.50.

WILLS, A. P., Vector analysis with an introduction to tensor analysis (unabridged republication of 1931 edition), New York, Dover Publications, 1958, xxxii + 285 pp. $1.75 (paperbound).

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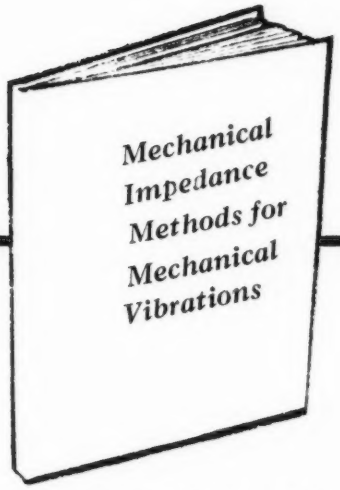

Designed to present the state of the art of impedance methods, this book gives precise definitions and shows how impedance methods apply to lumped and continuous systems of simple and moderate complexity, reviews measurement techniques, demonstrates the power of digital computers by comparing the calculated and measured characteristics of a highly symmetrical system of moderate complexity, gives measured values of typical structures of large size and high complexity, discusses the importance of the impedance in influencing shock and vibration spectra measured in field service, shows how to apply impedance methods to the calculation of vibration isolator effectiveness, treats impedance of some disordered systems, and illustrates how impedance methods may be used to find the response to random excitation.

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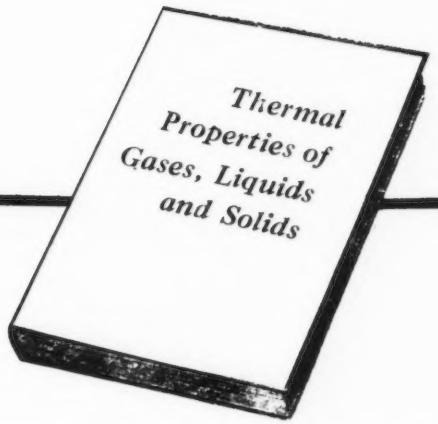

This book brings together the forty-two papers which were presented at the February 1959 Symposium sponsored by theASME Heat Transfer Division.

Covering special areas within the broad field of thermal property research, these papers survey the present theoretical and experimental state of the science; indicate the gaps of knowledge existing in both transport and thermodynamic properties, particularly at high temperatures and at high or even moderate pressures; report a large amount of new data; discuss new and improved experimental and theoretical techniques; review and evaluate the present state of knowledge in the specific areas covered.

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